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# A Study and Review of the **COMMON INDIAN SANDGROUSE** and the **IMPERIAL SANDGROUSE**



**UNITED STATES DEPARTMENT OF THE INTERIOR**  
**FISH AND WILDLIFE SERVICE**  
**BUREAU OF SPORT FISHERIES AND WILDLIFE**  
Special Scientific Report--Wildlife No. 84

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, SECRETARY

Frank P. Briggs, Assistant Secretary for Fish and Wildlife

Fish and Wildlife Service

Clarence F. Pautzke, Commissioner

Bureau of Sport Fisheries and Wildlife

Daniel H. Janzen, Director



The United States Department of the Interior, created in 1849, is concerned with management, conservation, and development of the Nation's water, wildlife, fish, mineral, forest, and park and recreational resources. It has major responsibilities also for Indian and Territorial affairs.

As America's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States, now and in the future.

On the cover

Female common Indian sandgrouse.

# **A Study and Review of the COMMON INDIAN SANDGROUSE**

by

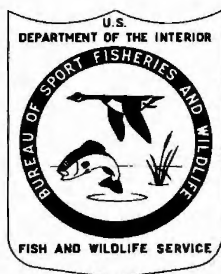
Glen C. Christensen  
Nevada Fish and Game Commission  
and

Wayne H. Bohl  
Bureau of Sport Fisheries and Wildlife

## **and the IMPERIAL SANDGROUSE**

by

Gardiner Bump and Wayne H. Bohl  
Bureau of Sport Fisheries and Wildlife



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## THE FOREIGN GAME INTRODUCTION PROGRAM

Year by year the number of individuals seeking relaxation through hunting is increasing. Yet the area available for this sport is slowly decreasing. Likewise, much of the habitat which mothers the game crop is becoming less and less able to produce shootable surpluses under an impact of clean farming, over-grazing, drainage, power equipment, increased use of insecticides and herbicides, scientific forestry, urbanization, and declining soil fertility.

Faced with this situation, common sense dictates an all-out effort to increase habitat productivity. There are many habitats which have been so thoroughly changed by man that native species can no longer maintain themselves therein in numbers sufficient to provide good hunting. Competing interests and the cost of reversing this trend are such that only a part of these lands can be restored to reasonable productivity in the foreseeable future. There are other coverts which never were fully occupied by native game birds or mammals possessing the characteristics requisite to survival in the face of today's intensive hunting pressure. For these, new, adaptable species possessing a high hunting resistance should be sought, so that such areas might provide greater hunting opportunities. This is the logic behind the foreign game introduction program as developed cooperatively by the U. S. Fish and Wildlife Service, cooperating State Fish and Game Commissions, and the Wildlife Management Institute.

The program is based on requests for assistance from State Fish and Game Commissions following an ecological appraisal of their game deficient habitats. After such information is in hand, biologists are assigned to make a careful study of game species occupying similar habitats and climates in foreign countries. From dozens considered, one or two may be selected on the basis of their characteristics, habits, reproductive capacity, resistance to predation and disease, relationship to agriculture, ability to withstand heavy hunting pressure, and the possibility of competition with game species native to the United States. Modest, carefully planned trial introductions of these species, utilizing wild-trapped or farm-raised individuals, carefully quarantined before shipment are then carried out in cooperation with interested State Fish and Game Commissions. Unplanned or "hit and miss" introductions are actively discouraged.

# CONTENTS

	<u>Page</u>
THE FOREIGN GAME INTRODUCTION PROGRAM.....	ii
FOREWORD.....	v
ABSTRACT.....	vii
SANDGROUSE IN GENERAL.....	1
Taxonomy and Distribution.....	1
Genus and Species.....	2
Introductions.....	5
THE COMMON SANDGROUSE OF INDIA.....	5
Common Names.....	5
Distribution and Relative Abundance.....	6
Description.....	6
Adult Male.....	6
Female.....	8
Weight.....	8
Habitat and Cover Preferences.....	8
Climatic Comparisons.....	10
Food and Water.....	14
General Habits.....	15
Movements and Mobility.....	15
Wariness.....	17
Resting and Roosting.....	17
Nesting and Renesting.....	17
Eggs.....	17
Brooding and Rearing.....	18
Gregariousness.....	18
Calls.....	18
Predation.....	18
Reproductive Capacity.....	18
Diseases and Parasites.....	19
Analysis of Competing Interests.....	19
Relation to Agriculture.....	19
Usefulness.....	19
Relation to Other Game Species.....	22
Breeding and Raising.....	22
Trapping.....	22
Releases in the United States.....	23
Potential Adaptability to the United States.....	26
THE IMPERIAL OR BLACK-BELLIED SANDGROUSE.....	27
Taxonomy and Distribution of the Subspecies.....	28
Introductions.....	30
Common Names.....	30
Distribution and Abundance.....	30
Description.....	32
Adult Male.....	33
Adult Female.....	33
Juvenile Male.....	34
Size and Weight.....	34

	<u>Page</u>
Habitat and Cover Preferences.....	34
Cover.....	34
Topography.....	40
Soils.....	41
Climate.....	41
Of the summer range.....	41
Of the winter range.....	42
Of the "resident" range.....	42
Climatic comparisons.....	46
Food and Water.....	47
General Habits.....	52
Migrations, Movements and Mobility.....	52
Flight.....	54
Wariness.....	54
Resting and Roosting.....	54
Breeding.....	54
Nesting and Renesting.....	54
Eggs.....	56
Brooding and Rearing.....	56
Gregariousness.....	56
Psychology and Behavior.....	57
Calls.....	57
Interbreeding.....	57
Predation.....	58
Reproductive Capacity.....	58
Diseases and Parasites.....	59
Analysis of Competing Interests.....	59
Relation to Agriculture.....	59
Usefulness.....	59
Relation to Other Game Birds.....	61
Breeding and Raising.....	62
Trapping.....	62
REFERENCES.....	69



## FOREWORD

There are extensive habitat types within the vast, semiarid regions of the western United States which are largely deficient of native game birds. During the past 10 years, Foreign Game Introduction personnel have explored the possibility of locating foreign species which might prove adaptable to such areas. Specifically, what is needed in the West where no upland game bird thrives today, is either a sedentary species or a semimigratory game bird that has been accustomed to habitat extremes. This species must be able to endure freezing winter temperatures, occasionally with snow, and summer droughts in areas where watering sources are limited. Food conditions for a new game bird might be good in certain years, or in other years there might be a minimum of grass and forb growth with perhaps some dry upland grainfields. It is not difficult to envision that few sedentary upland game birds of the world would be able to tolerate all of these seasonal habitat hardships. It would appear that a migratory or semimigratory bird, which has the ability to range over many miles in search of food and water, has the best chance of fitting into the habitat described.

A number of species that thrive under annual precipitation levels of 5 to 27 inches have been studied, but only two groups, the bustards and the sandgrouse, both of which may meet some of the standards noted above, have been located to date. Among the bustards, which are distributed in Europe, Asia, and Africa, only four, the European bustard, the great Indian bustard, the houbara, and the little bustard, have been observed by program biologists. None of these seems to offer exceptional promise. The sandgrouse family is larger and more widely distributed. Two genera, containing 16 species, and 29 subspecies, ranging from Europe and Asia through Africa have been described (Baker 3, Peters 31, Ripley 32). Some species are migratory, and even the resident species may move about over a considerable area, sometimes in flocks of thousands.

During the course of program studies, six of the species, found in Europe and/or southern Asia, have been evaluated, and attention has focused on two, the common sandgrouse of India (Pterocles exustus hindustan) and the imperial sandgrouse (P. orientalis). Both provide excellent sport, are abundant over a large range, and occupy habitats similar in many respects to the semiarid regions of the western United States. Program operations in India and Pakistan provided an opportunity to secure life history data on the common Indian sandgrouse. Its larger relative, the imperial sandgrouse was studied, though not as intensively, in Spain, Turkey, Iraq, Iran, Afghanistan, and northwestern India by program personnel. On the basis of this work, trial introductions of the common Indian sandgrouse were made in 1960-62 in the States of Nevada and Hawaii. This report presents the data accumulated to date and evaluates the potential of both species for introduction.

Glen C. Christensen, Wildlife Specialist, Nevada Fish and Game Commission, conducted the major studies on the common Indian sandgrouse in the Thar Desert, India, while working as a cooperator with the Foreign Game Introduction Program during the period 1959-1961. The junior author's contribution to the report covers his observations of sandgrouse in the 25 to 30 inch rainfall area of north central India during the same period. The sandgrouse release areas in Nevada are covered by Christensen and those in Hawaii by Bohl.

The section on the imperial or black-bellied sandgrouse was prepared by Gardiner Bump, who has observed this species over most of its range, supplemented by information contributed by Bohl and Christensen.

## ABSTRACT

This report summarizes the taxonomy and distribution of the sandgrouse family (Pteroclididae) in Europe, Asia, and Africa. Two representatives, the common Indian sandgrouse (Pterocles exustus hindustan) and the imperial or black-bellied sandgrouse (Pterocles orientalis) are singled out for detailed consideration because trial releases of these into the western United States have been made or are contemplated. Topics covered include descriptions, habitats, climatic requirements, food and water, general habits, effect of predation, reproductive capacity, and diseases and parasites. Also considered are their relation to agriculture and to other game species together with notes on the breeding, rearing, and trapping of these sandgrouse.



Female imperial sandgrouse

## SANDGROUSE IN GENERAL

Sandgrouse are a unique group of birds belonging to the order Columbiformes. The original common name "sand grous" (which was used because the birds have feathered legs) is actually a misnomer since these birds are not grouse, but are closely related to pigeons and doves. To further separate them from grouse in the mind of the reader, the common name here adopted is sandgrouse. Sandgrouse are short legged, long winged, and like many pigeons and doves, are capable of powerful flight over long distances. They have 11 primaries as contrasted with 10 for the Galliformes. Two to three eggs are laid, and the young, unlike pigeons, are precocious. It is suspected that with many species both sexes incubate and help rear the young. The sexes are easily differentiated by the color of the plumage.

Sandgrouse are birds of desert and steppe countries. Some species will fly great distances to water. Similarly, these birds have the ability to move immense distances for the purpose of obtaining food or to reach breeding or wintering grounds. This is well illustrated by the large pin-tailed sandgrouse (Pterocles alchata caudacutus) about which Baker (3) reports, "When ripe the seeds of a plant, Polygonum argyrocoleum, which grows over an immense area in the Tigris and Euphrates Valleys, forms the sole food of the Sand Grouse and the birds resort to these places in myriads for breeding purposes, often coming great distances. Their young reared and the seeding of the Polygonum finished, the birds move elsewhere, again clear the ground of the special foods available and then once more move off. During heavy rains and extreme droughts similar movements occur."

Peters (31) states that there are 2 species of sandgrouse in the genus Syrrhaptes (which have feathered legs and toes) and 14 species with 29 subspecies, in the genus Pterocles (which have feathered legs only). Sandgrouse are distributed from Portugal, Spain, and southern France southwards through Africa and eastwards through Asia Minor, southern Russia, Tibet, Afghanistan, West Pakistan, and India.

### Taxonomy and Distribution

Peters (31) classifies the sandgrouse as shown below. Mackworth-Praed and Grant (22) have put several of the sandgrouse into a third genus Eremialector. To provide continuity with previous reports, Peter's classification is followed here.

Order  
Family  
Genus

Columbiformes  
Pteroclididae  
Syrrhaptes  
Pterocles

Genus and species

Syrrhaptes

Syrrhaptes tibetanus

Tibetan sandgrouse

Ladak, Tibet, Sikkim

Syrrhaptes paradoxus

Pallas' sandgrouse

Russian steppes, Mongolia

Pterocles

Pterocles alchata

Pin-tailed sandgrouse

Southern Europe, Africa,  
Asia Minor, Iran, Iraq,  
Afghanistan, West Pakistan,  
India

Pterocles namaqua

Namaqua sandgrouse

South Africa

Pterocles exustus

Common sandgrouse

North Africa, Arabia,  
Israel, Iraq, Iran, West  
Pakistan, India,  
Southwest Siberia

Pterocles senegallus

Spotted sandgrouse

North Africa, Southwest  
Asia, West Pakistan,  
Northern India

Pterocles orientalis

Imperial sandgrouse

Southern Europe, North  
Africa, Turkey, South-  
eastern Russia, Iran,  
Afghanistan, West Paki-  
stan, Northwestern India  
and Southwestern Siberia

Pterocles coronatus

Coroneted sandgrouse

North Africa, Iraq, Iran,  
Arabia, Afghanistan, West  
Pakistan, Northern India

Pterocles gutturalis

Yellow-throated sand-  
grouse

East Africa

Pterocles burchelli

Variegated sandgrouse

Southwestern Africa

Pterocles personatus

Masked sandgrouse

Madagascar

Pterocles decoratus

Black-faced sandgrouse

East Africa

Pterocles lichtensteinii

Close-barred sandgrouse

Africa, Arabia, Iran,  
Afghanistan, West Pakistan

Pterocles bicinctus

Double-banded sandgrouse

South Africa

Pterocles quadricinctus

Four-banded sandgrouse

North Africa

Pterocles indicus

Painted sandgrouse

India, West Pakistan

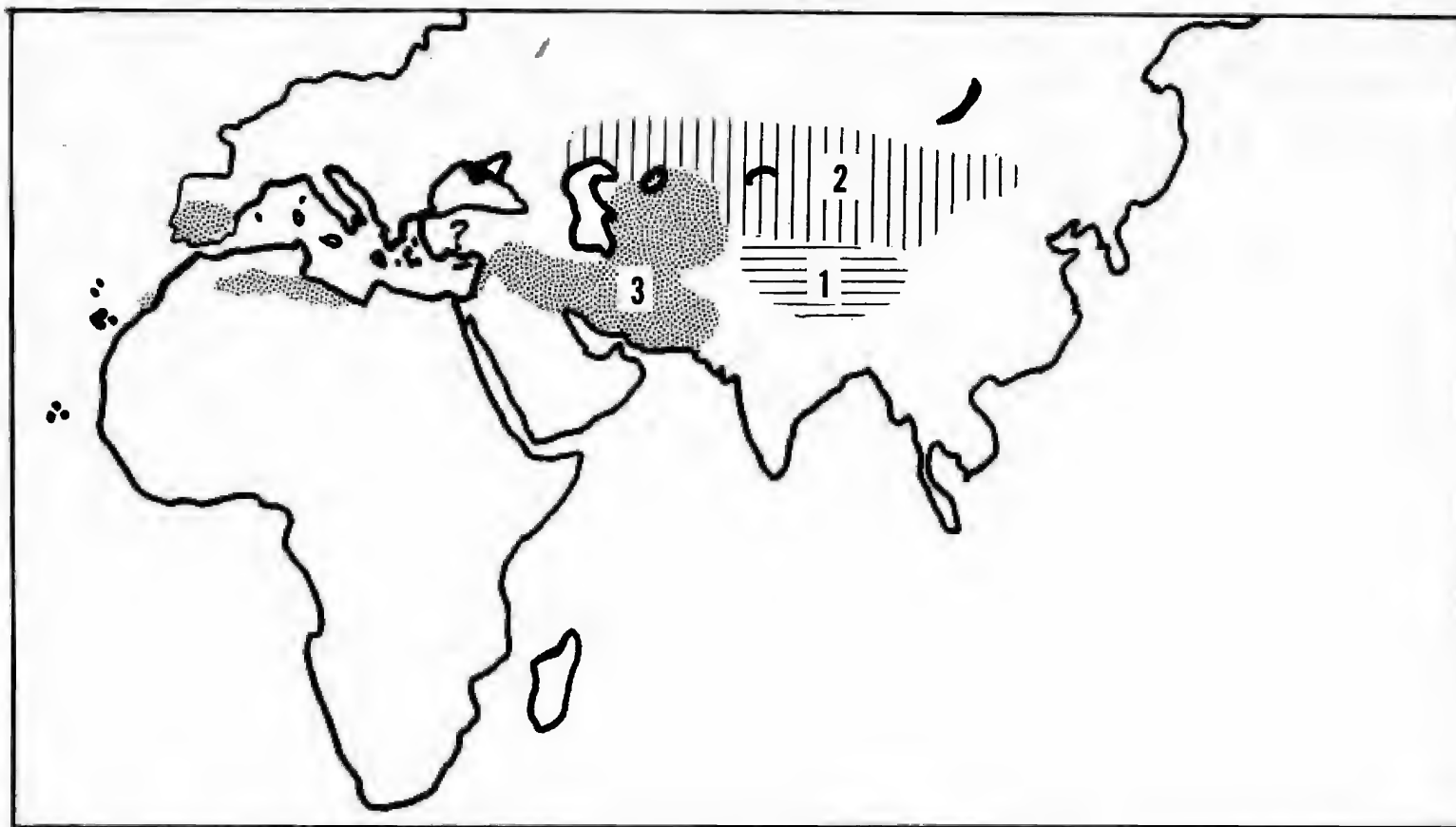


Figure 1. Distribution of two species of sandgrouse of the genus Syrrhaptes and one species of the genus Pterocles extending from Asia westward into North Africa, Spain and Portugal. 1. Syrrhaptes tibetanus; 2. S. paradoxus; 3. Pterocles alchata.

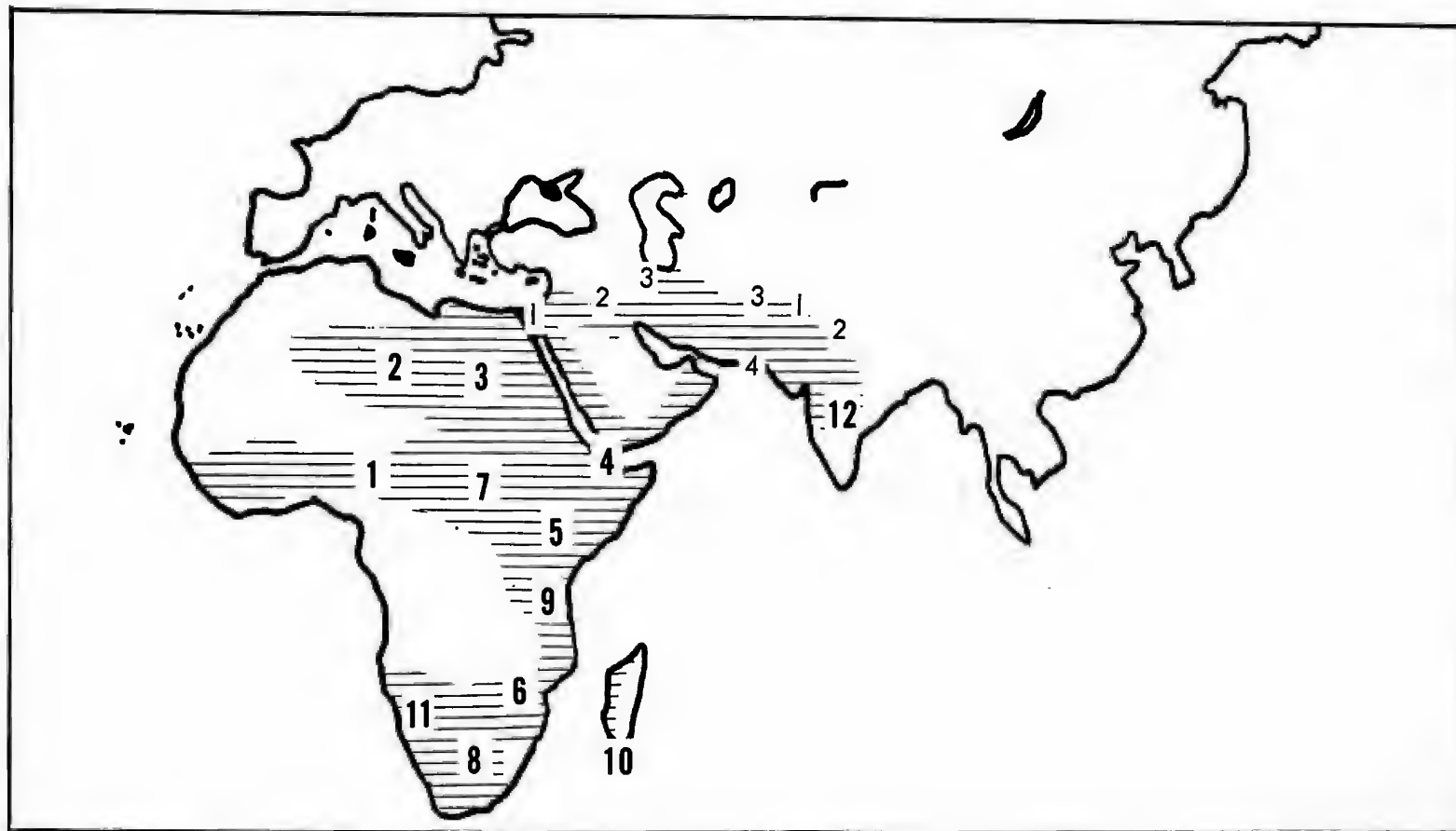


Figure 2. Distribution of twelve species of sandgrouse of the genus Pterocles in Africa and Southwest Asia. 1. Pterocles exustus; 2. P. senegallus; 3. P. coronatus; 4. P. lichtensteinii; 5. P. decoratus; 6. P. bicinctus; 7. P. quadricinctus; 8. P. burchelli; 9. P. gutturalis; 10. P. personatus; 11. P. namaqua; 12. P. indicus.



## Introductions

Grinnell and Miller (20) state that 21 sandgrouse (Pterocles sp.) were liberated on the edge of the Mohave Desert near Palmdale, Los Angeles County, Calif., in 1934. These birds were said to have been imported from Calcutta, India. The release was a failure. No information has been found concerning the introduction of sandgrouse into other areas of the United States. It is probable that some species have been placed periodically in zoos or aviaries. It appears, therefore, that until Program operations in India in 1959 no concerted effort had been made to release these birds in the wild in an attempt to establish them. During the Indian project substantial numbers of the common Indian sandgrouse, P. e. hindustan were introduced into the states of Nevada and Hawaii. A few imperial sandgrouse were also trapped and sent to the Utah State Game Farm for experimental breeding purposes.

## THE COMMON SANDGROUSE OF INDIA

This section of the report is concerned with the common Indian sandgrouse (Pterocles exustus hindustan). This race was selected after a general evaluation of its habitat, life history, abundance, and sporting qualities. During earlier studies the pin-tailed sandgrouse (P. alchata) was considered and disapproved by Bump because of its habit of forming enormous flocks that he deemed potentially dangerous to agriculture. Bump (personal communication), had also considered the painted sandgrouse (P. indicus) for introduction but states that it was nowhere abundant in its native range.

The common Indian sandgrouse is found in abundance in northwestern India and parts of West Pakistan in a habitat which strongly resembles many of the arid regions of the southwestern United States. Although this bird is considered a resident species, it is mobile and can range widely. It was felt that the combination of abundance, availability, and good sporting qualities, in conjunction with what appeared to be the ability to withstand the severe conditions of a desert environment, warranted substantial trial introductions of this bird into southern Nevada and later into Hawaii.

## Common Names

Some common names for this bird (most are in native dialects) are as follows: Common Indian sandgrouse (English), common sandgrouse (English), small pin-tailed sandgrouse (English), bhat-titar (Hindi), bakht-titar (Hindi), kuma-tit (Hindi), kakar (Hindi), dangar (Hindi), bowri (Hindi), butabar (Sindi), batibun (Sindi), popandi (Bhil), pakorade (Marathi), jam polanka (Telegu), kal-gowjal-haki (Mysore), and kal-kandari (Tamil).

## Distribution and Relative Abundance

The common Indian sandgrouse is one of seven subspecies mentioned by Peters (31). It is distributed through West Pakistan and the drier parts of India. Baker (3) believes that the Indian variety is identical to P. e. erlangeri which inhabits southern Palestine, the Syrian Desert and Iraq.

In India, the common sandgrouse is most abundantly found in the Thar or Sind Desert. Here, during the summer period when water is restricted, it is not uncommon to find as many as 2,000 to 3,000 birds drinking at a single waterhole. During the monsoons, when water is more widespread, the birds travel in smaller flocks numbering up to 30 or 40 birds. Although large concentrations of common sandgrouse are found in the Thar desert, Hume (21) referring to other regions of India, states that "The common sandgrouse, though very frequently met with in considerable packs numbering from twenty to two hundred individuals, is never, so far as my experience goes, seen in those enormous flocks which P. alchata and, in a somewhat lesser degree, P. arenarius <sup>(a)</sup> affect. In all parts of the country where I have shot them, I have most frequently seen them in parties of from five to thirty." Observations by Program personnel in the Agra-Delhi area also indicate that the common sandgrouse is found in this region only in scattered numbers.

## Description

The sexes of the common sandgrouse can easily be distinguished on the basis of coloration and Baker (3) presented a detailed description as follows:

### Adult Male

"Crown to upper tail-covert isabelline-grey or isabelline-brown, darkest on the coverts, palest on the crown; lores, cheeks, chin, and throat dull yellow-ochre, often tinged with orange-buff, extending to form a collar around the neck, but shading off into the other parts; scapulars and interscapulars darker and shading into ochreous-buff at the tips, which are edged with brown; greater secondary coverts and inner secondaries buff or ochreous-buff, the latter shaded with olive on the inner webs and inside of outer webs; inner lesser coverts like the back, gradually changing to buff or ochreous on the remaining lesser, median and greater coverts, which are also margined with paler buff; edge of wing, winglet, primary coverts and primaries dark brown, the inner primaries with broad, oblique bands of white at the ends; outer secondaries brown; upper breast vinous-buff, divided from the lower breast by a narrow band of black bordered with white; lower breast dull yellow-buff, changing gradually into the chocolate of the rest of the lower plumage and the black of the centre of the abdomen; under tail-coverts and tarsi creamy-buff; central tail-feathers like the back, becoming black on the prolonged narrow portions; outer tail-feathers tipped with pale buff and with some dark freckling next to the tip on the outermost pair."

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(a) P. arenarius is a synonym of P. orientalis.



Figure 3. Common sandgrouse in New Delhi holding pen.



Figure 4. Excellent sandgrouse habitat near Jaisalmer, India. Open grassy desert plain in the 5 to 10 inch rainfall zone.

## Female

"Upper plumage dull buff, streaked with marks of dark brown, on the hind-neck these increase to blotches and on the back and other parts become broad bars; scapulars, inner secondaries, lesser and median coverts like the back but the feathers broadly tipped with buff and some of the coverts finely edged with brown; sides of head, neck and breast more vinous and strongly spotted with black; lower breast dull pale ochre-buff; abdomen, flanks and vent rufous-buff closely barred with very dark brown; under tail-coverts creamy buff.

"Colours of soft parts. Iris dark brown; orbital skin pale yellow to pale greenish-yellow; bill and feet slaty-grey to plumbeous or lavender-blue, claws blackish.

"Young birds have the whole of the upper parts dull buff, finely vermiculated all over with thin wavy lines of black; chin to breast earthy-buff finely barred with blackish; abdomen and flanks dull black; quills freckled with buff at the tips and inner secondaries freckled all over; greater and median coverts black edged with dark buff.

"Nestling in down. Above pale ginger broken by white patterns and lines, pricked out in black; underparts isabelline-white, darkest on the throat; the pattern on the head and on the back assumes the shape of a figure eight."

## Weight

Baker (3) gives the weights as: males, 8 to 10 oz.; females, 7.5 to 8.5 oz. Sixteen birds were collected by Christensen in the Thar Desert and the weights were 6.5 to 8.25 oz. for the males and 6.0 to 7.5 oz. for the females.

## Habitat and Cover Preferences

Prime common sandgrouse habitat occurs in northwestern India where the annual precipitation varies from a low of approximately 5 inches in the vicinity of Jaisalmer to slightly over 14 inches at Jodhpur. The common sandgrouse inhabits the vast desert flats in areas where the vegetation is often sparse and water scarce. The principal vegetation is a scattering of thorny shrubs (Acacia leucophloea, Ziziphus sp. and Capparis aphylla) with an understory of grasses and weeds. Calatropis sp. are found in abundance. In the drier western reaches of the Thar Desert the rocky soil, desert pavement, and general characteristics of the vegetation are almost typical of what one would see in many of the southwestern deserts in the United States. Sandgrouse abound in this region. A food crop of leguminous forbs seems to be particularly necessary, and the annual crop of grasses and forbs depends upon the summer monsoon rains. Periodic droughts, which have an effect upon the extent and success of the vegetation, do occur. In the Thar Desert limited dry farming of millet, pulse, and wheat occurs where practical, and although the common Indian sandgrouse is often found in association with cultivated lands (primarily fallow fields) it is not dependent upon agriculture.



Figure 5. Sandgrouse utilize fallow fields and adjacent wasteland near Jodhpur, India in a 10 to 15 inch rainfall zone.



Figure 6. Scattered populations of sandgrouse utilize wasteland between brush patches and intense agriculture near Agra, India, in a 25 to 27 inch rainfall zone.

Further to the east into north-central India, where precipitation reaches 27 inches per year, this species is not uncommon although the the flocks are smaller and more scattered than in the drier Thar Desert. An example of conditions here is the area surrounding Agra and New Delhi where suitable habitat is limited to flat or rolling semiarid patches of wasteland checkerboarded in between and surrounding rather extensive plots of cultivated lands. Because of the high utilization of flat lands for agriculture, eroded areas or bench lands at the foot of low, rolling hills serve as the primary habitat for the common sandgrouse. The vegetation of these areas is similar to that found in the Thar Desert, being thorny brush with an understory of grasses and forbs. Since the common sandgrouse shys away from dense vegetation and mountainous terrain, fallow fields form a much more important part of the habitat complex in this region than they do in the Thar Desert.

The common Indian sandgrouse does not rely on escape cover. The natural protective coloration of this species blends in well with desert sand and rocks. This bird is strong on the wing and seems to prefer to remain in open country, where visibility is good, and depends upon its quick powers of flight for protection.

#### Climatic Comparisons

As previously mentioned, Program studies in northwestern and north-central India and West Pakistan showed that annual precipitation in common Indian sandgrouse habitat ranged from a low of 3 inches to a high of 27 inches. There are reports of this bird being found in other parts of India and as Baker (3) put it they "occur practically everywhere in the plains where the rainfall is not too heavy." In general it appears that as precipitation increases from arid to the upper reaches of the semiarid classification, with the result that land utilization for agriculture becomes more intensive and brush vegetation becomes more abundant on wasteland, the amount of common sandgrouse habitat decreases proportionately. Similarly, common sandgrouse are more numerous in the drier regions and less abundant where the precipitation is higher. Precipitation throughout the range of the common sandgrouse in India is of the monsoon type, and in many respects is not unlike the pattern found in portions of the semiarid regions of the southwestern United States.

The seasonal range of the mean maximum and mean minimum temperatures in a portion of common Indian sandgrouse habitat in southwest Asia is presented in table 1. These resident areas extend from central India and the Thar Desert of India westward into Sind and Baluchistan in West Pakistan.

Table 1. Range of mean maximum and mean minimum temperatures in common sandgrouse habitat in India and West Pakistan (a)

Season <sup>(b)</sup>	India				West Pakistan			
	<u>Central India</u>		<u>Thar Desert</u>		<u>Sind</u>		<u>Baluchistan</u>	
	Mean Max.	Mean Min.	Mean Max.	Mean Min.	Mean Max.	Mean Min.	Mean Max.	Mean Min.
Winter	73-78	43-46	76-81	49-53	76-81	51-54	54-58	29-33
Spring	89-107	55-77	90-105	61-79	92-107	64-78	74-80	46-54
Summer	92-105	78-83	92-103	77-82	96-104	79-82	92-98	62-74
Fall	85-94	48-75	87-95	55-75	89-98	59-76	76-82	40-52

(a) Temperatures in degrees F.

(b) Winter, December-February; Spring, March-May; Summer, June-August; Fall, September-November.

In Baluchistan common sandgrouse nesting areas are usually above 4,000 feet, with winter and summer temperatures colder than in the lower elevations of the Thar Desert. The main breeding season in Baluchistan is during the spring months.

Over the range of the common Indian sandgrouse the air temperatures are high in the summer, with extremes reaching 120°F., and mild in the winter. Minimum temperatures seldom reach the freezing point. There is considerable variation in the diurnal temperatures, though this is not quite as marked as in some of the deserts in the southwestern United States

Table 2 depicts temperature and precipitation records for Jodhpur and Agra, India. These two stations represent areas where large populations are found (Jodhpur) and where scattered populations occur (Agra). The Jodhpur precipitation reports are somewhat higher than occur in the interior of the Thar Desert where excellent sandgrouse populations are also found. Climatic data for Overton, Nev., and Pohakuloa, Hawaii, are included to present an idea of climatic conditions in the release areas of the United States. Pohakuloa represents the nearest weather station to the Hawaiian release sites. These conditions are not necessarily representative of the climate at other potential release sites in the southwestern deserts of the United States. An evaluation of the effects of climate on the common sandgrouse, released in the United States, is presented on page 26.

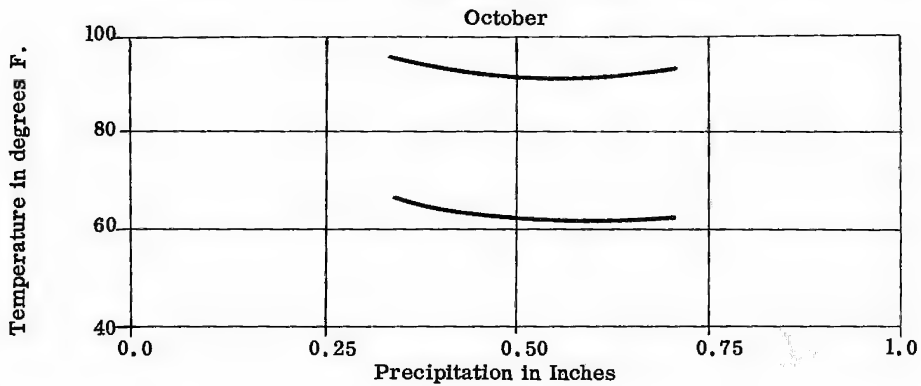
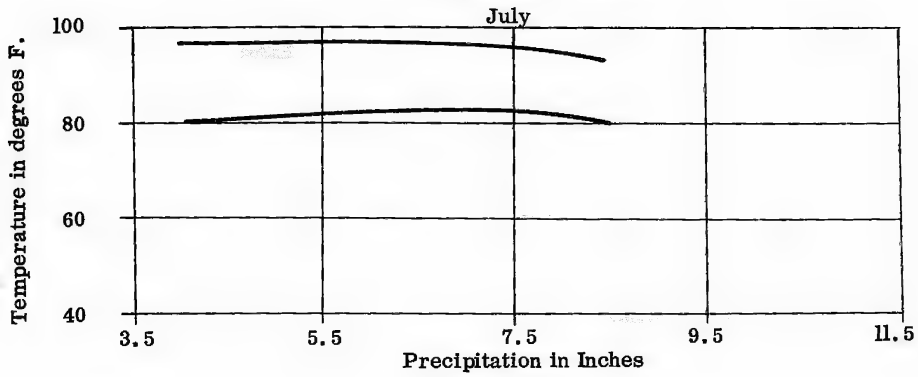
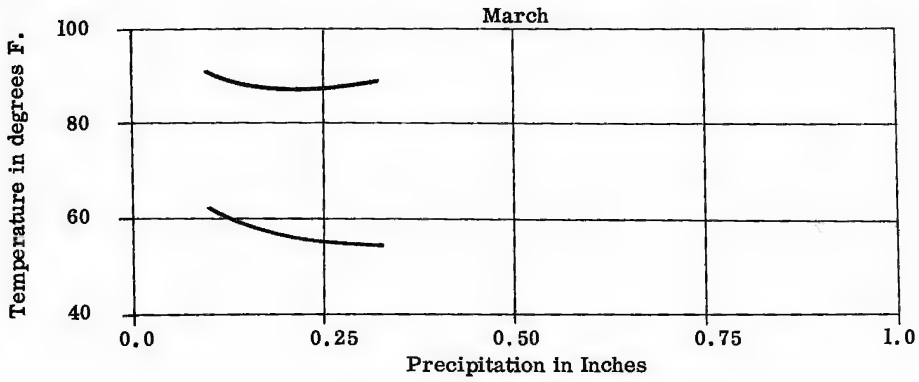
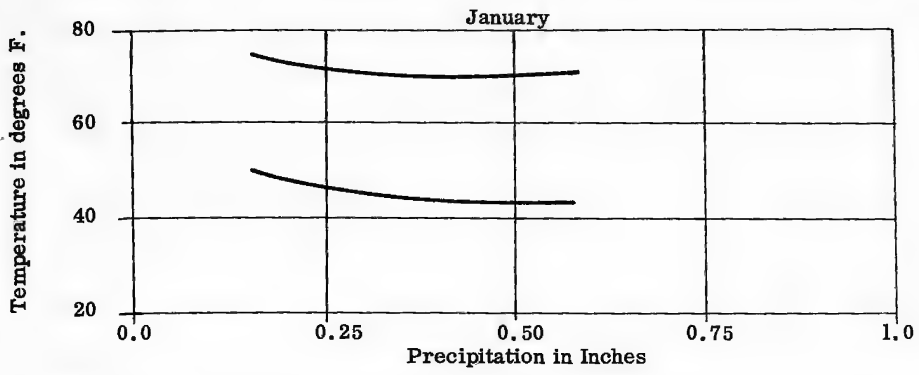
Table 2. Climatic comparisons between Jodhpur and Agra, India representative of native common Indian sandgrouse habitat, and Overton, Nevada and Pohakuloa, Hawaii two United States trial release areas.

Month	Jodhpur			Agra			Overton			Pohakuloa		
	Mean max.	Mean min.	Mean pre-cip.	Mean max.	Mean min.	Mean pre-cip.	Mean max.	Mean min.	Mean pre-cip.	Mean max.	Mean min.	Mean pre-cip.
Jan.	76	39	0.15	73	43	0.57	59	31	0.57	73	35	0.11
Feb.	81	53	0.24	78	46	0.49	65	35	0.53	72	34	0.67
Mar.	91	62	0.11	89	55	0.32	72	40	0.51	71	37	0.77
Apr.	99	71	0.13	101	67	0.21	85	49	0.34	73	36	0.49
May	105	79	0.41	107	77	0.38	94	58	0.13	78	39	0.71
June	104	82	1.42	105	83	2.44	102	64	0.02	70	41	0.00
July	97	80	3.97	95	80	8.55	110	71	0.19	78	40	0.63
Aug.	92	77	4.84	92	78	8.11	107	71	0.41	76	42	0.70
Sept.	94	75	2.40	93	75	4.58	101	62	0.57	77	42	0.91
Oct.	96	65	0.32	94	62	0.71	86	50	0.41	72	34	1.60
Nov.	88	55	0.11	85	48	0.14	70	37	0.31	73	33	3.84
Dec.	79	51	0.11	76	43	0.30	62	32	0.80	71	35	2.65
Annual	92	67	14.21	91	63	26.74	84	50	4.79	74	37	13.08

Note: 1. Temperatures are given in degrees F.; precipitation, in inches.  
 2. The elevation of Jodhpur is 736 feet; Agra, 500 feet, Overton, 1,120 feet and Pohakuloa, 6,500 feet.

Climacurvic comparisons, based on available data from the Thar Desert and from central India, are presented in Figure 7. These comparisons present the mean maximum, and mean minimum temperatures in relation to precipitation in the native habitat of the common Indian sandgrouse. Smoothed curves drawn for each month represent the upper and lower limits of mean maximum and mean minimum temperatures in relation to average annual precipitation. Four separate months of the year are shown. January is a dry winter month; March is also dry and one of the main nesting months for Indian sandgrouse; July is a moderately to very wet monsoon period and October a fairly dry but warm fall month. Mean maximum and mean minimum temperatures for fall, winter, and spring will often average 10 to 12 degrees colder in the southwest and in Hawaii than in India. The mean maximum July temperature in Nevada is at least 10 degrees warmer and the mean minimum temperature in Nevada is as many degrees colder than they are for the same period in India. Hawaii temperatures for this summer period are cooler in mean maximum and mean minimum temperatures than are those recorded for common Indian sandgrouse range.





**Figure 7 -- Mean maximum and minimum temperatures in relation to precipitation in common Indian sandgrouse habitats in India over four important months.**

## Food and Water

For food-habits studies 47 sandgrouse crops were collected in West Pakistan and northwestern India. Of these crops, 7 were taken near Karachi, 30 from the Thar Desert, and the rest from the region near Delhi and Poona. An analysis of these crops has been given by Faruqi et al (18) and Christensen (13) and are combined in table 3. The common Indian sandgrouse are selective feeders. They are primarily seed eaters and prefer small seeds, in large numbers, usually from leguminous plants. No insects were found in the crops examined.

Table 3. Foods eaten by the common sandgrouse in West Pakistan and India according to season and number of crops in which each was found (from 13, 18).

<u>Foods</u>	<u>Season</u>			
	<u>Spring</u>	<u>Summer</u>	<u>Fall</u>	<u>Winter</u>
<u>Plant Seeds</u>				
<u>Alysicarpus</u> sp.	2	3	5	
<u>Amaranthus</u> sp. (amaranth)				1
<u>Crotalaria</u> sp. (rattlewort)	1			6
<u>Cyamopsis</u> <u>psoralioides</u>				2
<u>Desmodium</u> sp. (beggarweed)				3
<u>Euphorbia</u> sp. (spurge)		1		
<u>Gynandropsis</u> <u>gynandra</u>				5
<u>Heliotropium</u> <u>strigosum</u> (heliotrope)	2	6	7	4
<u>Indigofera</u> <u>anabaptista</u> (indigo)	1	3		
<u>Indigofera</u> <u>cordifolia</u> (indigo)	2	5	1	1
<u>Indigofera</u> <u>enneaphylla</u> (indigo)			2	2
<u>Indigofera</u> <u>linifolia</u> (indigo)	4	7	8	9
<u>Indigofera</u> <u>uniflora</u> (indigo)	1	4		
<u>Panicum</u> <u>antidotale</u> (panicgrass)			6	
<u>Panicum</u> sp. (panicgrass)				5
<u>Panicum</u> <u>turgidum</u> (panicgrass)			1	
<u>Phaseolus</u> <u>radiatus</u> (pulse)				4
<u>Tephrosia</u> <u>purpurea</u> (legume)	4	6	3	6
<u>Tephrosia</u> sp. (legume)			1	
<u>Tephrosia</u> <u>strigosa</u>			5	10
<u>Tephrosia</u> <u>tenuis</u> (hoary pea)	2	2		
Unidentified (grass) blades	2	1		
<u>Miscellaneous</u>				
Grit	3	5	6	6

From table 3 it may be noted that common sandgrouse prefer wild seeds to cultivated grains; however, cultivated seeds (Phaseolus and Cyamopsis) are eaten in minor quantities. Seeds of Indigofera and Tephrosia appear to be highly preferred. Great quantities of seeds are consumed by individual birds as can be seen from the following example from Faruqi et al (18): "In the crop of one bird, collected on March 12 near Karachi (Pakistan), there were about 5,600 seeds of Indigofera cordifolia, 51 seeds of Tephrosia tenuis, 89 of Indigofera uniflora, and 9 of Indigofera anabaptista. The crop of another bird, collected on February 8 at Sambhar Lake, Rajasthan (India), contained about 10,000 seeds of Indigofera linifolia, 350 of Crotalaria sp., 1 of Tephrosia purpurea, 5 of Phaseolus radiatus, and slightly over 100 seeds of species as yet unidentified."

The common sandgrouse waters regularly every day. In the Thar Desert, water is scarce and the birds tend to concentrate at available water sources. Generally the only water present is rainwater which is captured in large depressions in the earth. Such waterholes are commonly called tanks. The first group of sandgrouse can usually be seen flying toward the tank about 1 hour after sunup. These birds generally land on a nearby flat where they are joined at intervals by other flocks of birds. About 2 to 3 hours after sunup, depending upon the prevailing temperatures, the birds rise as a group and circle over the waterhole. If the waterhole is in an undisturbed area, they will then land near the shore and walk to water. If the waterhole is disturbed by the presence of people and animals as often is the case, they will quickly land at the water's edge, or sometimes in the water, drink and fly. During the summer months, at which time many of the smaller tanks dry up, tremendous concentrations of sandgrouse may utilize the few existing watering sites.

Baker (3) states that the common sandgrouse will also water a second time during the evening before sunset. During the Project's trapping operations in the Thar Desert, the common sandgrouse was observed only occasionally to water at sunset. Early morning watering, once a day, appeared to be the rule.

### General Habits

#### Movements and Mobility

Many of the species of sandgrouse are migratory. The common Indian sandgrouse seems to be of a more sedentary nature, however, extensive local movements can be expected. During the summer, when many tanks go dry, the birds move to adjacent areas where water is still available. It also appears that periodic movements, over extended distances, occur in relationship to the available food supply.

No detailed information is available in regard to the daily movements of the sandgrouse. Observations, when trapping, indicated that the birds would fly up to 10 miles to water.



Figure 8. A typical waterhole or "tank" which is utilized by the common sandgrouse in the Thar Desert.



Figure 9. A common sandgrouse nest in a fallow field near Jodhpur, India.

## Wariness

Under normal field circumstances, common sandgrouse is an alert bird and flies quickly at the first sign of danger. When the birds are on their feeding, roosting and loafing grounds, in open desert country, a hunter on foot would find it very difficult to successfully bring them to bag. Like many animals, sandgrouse do not appreciate the dangers of a car. Hunters in India often drive across the open desert plains and shoot these birds from a vehicle. The daily and almost precise watering habits of sandgrouse leave them vulnerable on a second front. These birds apparently need to water daily, especially during the hot summer months. During this period of the year they will come to water regularly despite shooting or other disturbances. If the birds are disturbed for a prolonged period over several days, they will then move to another watering area, often a considerable distance away.

## Resting and Roosting

Common sandgrouse have been seen resting in the shade of small shrubs during mid-day when the weather was hot and dry. They roost on the ground on the desert plains and no direct observations were made in regard to their utilization of brush or scattered grasses and forbs as cover. The impression gained during night observation suggested that they preferred to roost in very open country with a minimum of cover. When startled these birds flush almost vertically upwards, and this flight would, of course, be hindered by overhead vegetation or shelter.

## Nesting and Renesting

The common Indian sandgrouse nests in open desert country and fallow fields with sparse stubble. The nest is simply a scratched out depression in the earth without a lining. No attempt is made to hide the nest, and it is usually in the open without cover of any type. Observations in the Thar Desert showed that the primary nesting period was from February to April. Three-quarters grown birds were trapped in each of these months indicating that the sandgrouse also nested in November, December and possibly January. Therefore the possibilities of renesting, and perhaps even of producing two broods a year, exist.

## Eggs

Three eggs per nest appear to be the general rule. Baker (3) describes the eggs as "pale grey-stone or yellowish-stone with numerous small blotches and spots of various shades of brown profusely scattered over the whole surface and with secondary markings of lavender and grey." Measurements of 200 eggs, as noted by Baker showed an average of 36.8 x 26.2 mm.

## Brooding and Rearing

It is suspected that both sexes incubate. Young sandgrouse are precocious and leave the nest shortly after hatching. The common sandgrouse often wades into water or actually lands in water when drinking and gets its belly feathers wet. This practice resulted in considerable speculation that the purpose is to transfer water back to the nest for cooling the eggs or watering the young. Meinertzhagen (26) presents a much more logical means of watering the young as follows: "Between 1895 and 1897 I kept several pairs in a large aviary in Hampshire, where they bred for two years in succession; water was taken to chicks in the crop, whence it was regurgitated, and though the belly was often wet there was no sign of chicks taking water from the abdominal feathers."

## Gregariousness

The common Indian sandgrouse is gregarious and is normally seen in flocks of from 5 to 40 or more birds. Unusual circumstances, such as restricted watering sites, will cause hundreds or even thousands of birds to congregate in large flocks.

## Calls

While flying, the common sandgrouse will constantly emit a "cluck-cluck" which can be heard for some distance and is helpful in locating the birds.

## Predation

Predators are numerous throughout sandgrouse habitat. Although ground predation may take place, no records are available. Several instances of falcons taking sandgrouse at waterholes have been witnessed. Predation in India seems to be a normal, inimical factor to which the sandgrouse populations have adjusted.

## Reproductive Capacity

The reproductive characteristics of the common sandgrouse strongly resemble those of pigeons and doves. A brief resume of the major breeding factors is:

Breeding age -- Common Indian sandgrouse breed the first year following hatching.

Number of eggs -- Normally 3.

Brood survival -- No definite information available. It appears to be good.

Life span -- No information available for wild birds. Wild-trapped adult birds have survived for 3 years in captivity in Nevada.

Sex ratio -- Appears to be equal.

Renesting -- It is indicated that they will renest if the first nest is destroyed.

Second broods -- It is strongly indicated that there are two major nesting periods during the year and that second broods are produced.

### Diseases and Parasites

Limited experience with diseases and parasites was gained during the trapping and holding operations in India, quarantine in the United States, and the brief holding period in Nevada before field release. The sandgrouse appeared to be considerably less disease prone than any of the gallinaceous game birds which were held under similar circumstances. During the holding period in Jodhpur these birds were on occasions exposed to Newcastle disease and fowl pox and did not appear to be susceptible to either. They seem to be relatively resistant to the more common communicable diseases characteristic of poultry.

Only one reference to parasites of Pterocles exustus was located. Singh (36) indicates that Maplestone found pin worms (Syphaciella indica) in these sandgrouse, collected in India.

### Analysis of Competing Interests

#### Relation to Agriculture

Some sandgrouse such as the pin-tailed have been observed by Bump (page 47) to descend upon cultivated fields in flocks containing thousands of birds. The exact extent of crop damage, if any, during these occasions is a subject of speculation. Nevertheless, crop damage or flocking in cultivated fields is a matter of concern, especially with regard to introducing a species where agricultural crops are common. To all appearances the common sandgrouse, though it does frequent areas of agriculture, is not injurious to crops. This species does not inhabit croplands when crops are growing or before the harvest since it does not like dense cover. It is seen on fields which have been cleared of the harvest or on fallow fields. Studies show that only a very low incidence of agricultural grains are utilized for food.

#### Usefulness

As a source of food -- The flesh of the sandgrouse is all dark meat. Although the common sandgrouse is a relatively small bird, the well developed breast muscles provide more meat than would be expected. Sandgrouse meat has a tendency to be dry, but when properly prepared it can be turned into a tasty meal.



Figure 10. The "clap-net" placed around a small waterhole for capturing the common sandgrouse.



Figure 11. The "clap-net", though hand-operated, is extremely quick to close.



Figure 12. Some of the "tanks" on which we trapped were fairly large.





Figure 13. Birds coming in to water.



Figure 14. Removal of sandgrouse from the clap-net.



Figure 15. Trapped sandgrouse, handled by the wings, did not struggle.

As a game bird -- The common Indian sandgrouse can provide thrills which will keep the most particular hunter alert and anxiously awaiting the day of the shoot. Hunting is commonly done at the waterhole, and this little fellow is a master of deception. His aerial acrobatics are a challenge to the best of nimrods. These small birds can carry a good deal of shot and hunting them has many of the pleasurable aspects of duck hunting, though on dry land.

#### Relation to Other Game Species

No direct competition has been seen in the field between the common Indian sandgrouse and other game species. During the winter period, when the imperial sandgrouse is present in India, both species of sandgrouse are found utilizing the same general habitat type. However, they do not comingle and they maintain species integrity during their daily activities.

The common sandgrouse seems to be a very docile bird and has been held without incident in captivity with grey francolin, black francolin and the imperial sandgrouse.

#### Breeding and Raising

Based on current attempts to propagate sandgrouse it now appears that both the common and imperial sandgrouse might be difficult to breed in captivity.

Between 1959 and 1961 the State of Nevada placed a total of 131 common and 21 imperial sandgrouse on the Utah State Game Farm at Price for breeding experiments. By the end of 1962, only one egg had been laid by the common sandgrouse and none by the imperials. Experimental game farm production of sandgrouse on the Price farm was discontinued in 1963.

Since the sandgrouse, so far, have not proved themselves suitable for game farm production, it would appear that any future releases in the United States would have to be made with wild-trapped birds.

#### Trapping

Birds were successfully trapped in large numbers at waterholes by using the clap net as described by Christensen (11). During the trapping operations it was found possible to "drive the sandgrouse, or to harass them to such a degree that they would land on a specific spot on the shoreline. Therefore, nets were placed at a few selected sites and people were stationed around the remainder of the shoreline to keep birds from watering anywhere except in net localities. Trapping was most successful when confined to tanks well isolated from other water sources. People were stationed at nearby untrapped tanks to harass the birds and prevent them from watering. Since sandgrouse are strong flyers, it was desirable during extended operations to control the watering of the birds in the above manner within at least a 5-mile circumference of the tank being trapped. This often involved the service of as many as 17 people daily.

"The success of the net is shown by the fact that 3,560 Indian sandgrouse were captured at 4 tanks in 2 trapping seasons. In January 1961, a record 400 birds were caught in a 2-hour trapping period with 3 sets on one tank. Just before this a rather exceptional catch was made of 37 of the larger and extremely wary imperial sandgrouse (Pterocles orientalis)."

Following capture the birds were quickly transferred into special carrying crates and transported to Jodhpur where they were conditioned in large holding pens for 2 months prior to being sent to the United States.

#### Releases in the United States

In the southwestern United States there are great expanses of arid "desert" land which are currently deficient of upland game populations. The search for a desirable species to fill this void centered around the sandgrouse primarily because they inhabited arid and semiarid regions of the Old World, could fly for long distances for food and water, and were highly prized as game birds. The common Indian sandgrouse was selected specifically because it not only had the above attributes but also was a resident species, instead of migratory, and it was found abundantly in desert areas of India and Pakistan which closely resembled game deficient habitat in southern Nevada and portions of Hawaii.

As a result of trapping operations in the Thar Desert during the period 1959 to 1962, a total of 2,826 common sandgrouse were banded and released in the states of Nevada and Hawaii. In addition, 131 birds sent to Nevada were placed on the Utah State game farm for experimental propagation. Table 4 gives a summary of the release data.

Table 4. Releases of common Indian sandgrouse in Nevada and Hawaii

Year	Number of birds released	
	Nevada	Hawaii
1960	991	-
1961	1,039	395
1962	-	401
Total	2,030	796



Figure 16. Common sandgrouse release site at Overton, Moapa Valley, Nevada.



Figure 17. Common sandgrouse release site near Pohakuloa, Hawaii.

Nevada -- In Nevada common sandgrouse were released in Pahrnatag Valley, Pahrump Valley and Moapa Valley. All these release sites are in the southern part of the State. Pahrnatag Valley is primarily pasture land with limited production of alfalfa. In Pahrump Valley cotton is the primary crop. In Moapa Valley intensive, diversified farming is practiced. In both Pahrump Valley and Moapa Valley, the adjacent uncultivated lands have a principal vegetation of quail brush (Atriplex lentiformis), honey mesquite (Prosopis juliflora), screwbean mesquite (Prosopis pubescens), and catclaw (Acacia greggii). Thickets of tamarisk (Tamarix gallica) occur in areas where the water table is high. There are vast expanses of desert wasteland throughout southern Nevada which have a dominant vegetation of bursage (Franeria dumosa), creosote bush (Larrea tridentata), and catclaw (Acacia greggii).

The sandgrouse released in Pahrnatag Valley in 1960 left immediately, and no further releases were made there. Releases were made in Pahrump and Moapa Valleys during the spring of 1960 and again in the spring of 1961. There was an initial exodus of birds from each release site immediately after the liberations. Some birds remained throughout the summer and early fall; with the advent of cold winter weather, these birds also left the release areas. No birds were found overwintering at any of the release sites.

Christensen (12) reports that on February 10, 1962, two sandgrouse, one from the 1960 and the other from the 1961 releases in Pahrump Valley, were shot at Navajoa, Sonora, Mexico. This leads one to suspect that the birds may have migrated to the desert regions southward.

Hawaii -- Between 1961 and 1962 trial liberations of the common Indian sandgrouse were made on the islands of Hawaii, Molokai, and Kauai. A total of 541 sandgrouse were released on Hawaii, and 255 birds were liberated on Molokai and Kauai.

One of the most favorable areas for release appeared to be near Pohakuloa, Mount Hualalai, and Ahumoa on the island of Hawaii. This general area ranges between 2,000 and 7,000 feet in elevation, and the rainfall averages 10 to 20 inches annually. In the Pohakuloa area and southward the lower-strata vegetation consists of grasses, legumes, and other herbs. Grazing constitutes the major land use between 4,000 and 8,000 feet and this practice results in cleared portions for grass growth and a scarcity of shrubs. As in western India, precipitation in this general area is slight and comes often as torrential rains, producing desert conditions suitable for only a limited number of plant species. According to Robyns and Lamb (33) the vegetation includes Myoporum sandwicense and Sophora chrysophylla. An arborescent, Raillardia sp., is common along the slope of Mauna Kea. Chenopodium sandwicense, growing to 15 or 20 feet in height, is found along the road to Humuula below the Myoporum-Sophora association. Also reported in varying abundance in the understory are bunch grass, Erigeron albidus, Verbena bonariensis, and Achillea millefolium. Other common shrubs reported by Rock (34) include the genera Coprosma, Dodonaea, Exocarpus, Stenogyne, Osteomeles, and Wikstroemia. Grasses found near Pohakuloa and Humuula include Eragrostis atropioides, E. grandis and E. lystophylla.

It was originally thought that sandgrouse might occupy the dry regions on the leeward side of Mauna Kea, particularly in the plateau parkland and the broad central plain between Mauna Kea, Mauna Loa, and Mount Hualalai. No sightings of sandgrouse have been made at the release sites, or elsewhere on the islands, since December 1962, and it is now believed that all releases in Hawaii resulted in failure.

### Potential Adaptability to the United States

The common sandgrouse, which appears to be a resident bird in India, has shown a marked tendency towards migrations of substantial distances following releases in Nevada. This may be the result of a normal reaction following release or it may be a reflection of possible inadequacies of the environment into which they were introduced. No migrations were recorded from Hawaii but the birds gradually disappeared. It would appear that this subspecies does not have the wide margin of adaptability which is apparent in gray and black francolins. Indian sandgrouse food habits are for the most part quite selective and it is possible that this subspecies also is not tolerant of extreme changes in temperature. In referring back to table 2 it can be seen that the mean minimum temperatures at Overton, Nev., are lower in every month of the year than are those at Jodhpur, India. Temperatures may be particularly critical in Overton during the months of November, December, and January when rather sharp temperature changes are accompanied by winter rains. Because the common sandgrouse, released in southern Nevada disappeared during the advent of cold winter rains it would seem that the winter temperature-precipitation relation in southern Nevada may be one of the major factors in preventing the establishment of this species here.

In Hawaii, at least near Pohakuloa, the minimum temperatures are cooler than those at Jodhpur, India. Fall and winter precipitation is heavy, in contrast to the summer monsoon precipitation pattern in the Thar Desert. Consequently, it seems that here also winter precipitation may be one of the important factors in limiting establishment of the common Indian sandgrouse.

There may be a place for this sandgrouse in the United States. Based on the experience to date, this place, if present at all, will most likely be south of southern Nevada where winter temperatures are warmer, or without cold winter precipitation, and where a more favorable summer precipitation pattern occurs.

Although this subspecies seems to have a narrow range of tolerance the advantages of establishing it or some other species of sandgrouse would seem to be worth the detailed investigations that are needed. It is possible that some species of sandgrouse may truly fit into large expanses of currently game deficient range, and thereby fully qualify to meet the objectives of the Foreign Game Introduction Program.

## THE IMPERIAL OR BLACK-BELLIED SANDGROUSE

The same general characteristics that make many other representatives of the sandgrouse family worthy of consideration as potential residents of semidesert wasteland areas in the western United States are found in the imperial sandgrouse. There are also some differences that should be noted. The imperial is among the largest of all the sandgrouse and is the most widely distributed. It nests further north than other members of the genus (Pterocles). It can withstand more cold and snow than other sandgrouse save only the Tibetan species (Syrrhaptes). It is resident in some areas though semimigratory over most of its range. It can exist for long periods on weed seeds smaller than the head of a pin but can also glean in fields from which wheat or other small grains have been harvested. Like other sandgrouse it will fly long distances to water, but it nests in open spots where the maximum summer temperature is usually somewhat cooler than that of the nesting habitat of other species of the same genus. In short, the imperial sandgrouse would seem to be more generally adaptable to temperate desert conditions than any other member of its family.

Preferred habitats include sandy, semiarid plains and rolling country either with or without a scattering of trees and shrubs. Dry farming areas are frequented. Here birds are seen on fallow ground, in stubble, or in fields overgrown with weeds and grass. Nesting areas are reported at elevations from less than 2,000 feet in Spain to 10,000 feet in Afghanistan.

A wide variety of climate is found throughout the summer and winter ranges of this species. Winter temperatures preferred are usually above freezing though birds in Turkey have been observed where temperatures very occasionally dropped to less than 20°F and snow covered the ground for upwards of a week at a time. Summer temperatures, though generally moderate in the nesting areas, range from a maximum of 85° to 90°F to a sizzling 110°F.

All sandgrouse prefer desert or semidry conditions. While average annual precipitation in imperial habitat varies from 2 to over 20 inches a year, this species will thrive in the presence of more moisture than is characteristic of the range of most sandgrouse.

A careful review of the literature, supported by 12 years of intermittent but substantial observations of this species by Program biologists, has uncovered no reason to believe that the imperial sandgrouse would compete unfavorably with native species or prove detrimental to agricultural interests in the United States, in the event of its successful introduction.

State game biologists in the western United States have often expressed an interest in locating game birds that might be adaptable to practically unoccupied desert or semiarid habitats. The imperial sandgrouse would seem to merit serious consideration in this search.

Possible trial areas include the short-grass prairies and/or dry wheatland farming regions of the western Great Plains as found in eastern New Mexico, Colorado, Wyoming, and the western parts of South Dakota, Nebraska, Kansas, Oklahoma and Texas. Suitable habitats also appear to be available seasonally in the hot or cold desert areas in and to the north and south of the Great Basin. Nesting might be expected to occur to the north in Washington, Oregon, Idaho, and Montana and on dry uplands further south where scattered weeds and grass predominate.

### Taxonomy and Distribution of the Subspecies

Few groups of game birds have been beset with more general confusion, taxonomically, than has the sandgrouse. The feathered legs and feet of the Tibetan species together with other general resemblances to ptarmigan probably were the genesis of the name sandgrouse. Very early attempts to classify them in the grouse family soon gave way to a belief that sandgrouse are more closely allied structurally with pigeons and doves. The British Museum's Catalogue of Game Birds (29) states that the Pterocletes (pigeon-grouse) form a well-marked order intermediate between the Columbæ (pigeons) and the Gallinæ or true game birds. Currently Pterocletes is placed as a suborder under the Columbiformes.

Sandgrouse are divided into two genera, Syrrhaptes and Pterocles. Imperial sandgrouse belong to the latter. Only one species, orientalis, and two subspecies, orientalis (a) and koslovæ (b), are generally recognized. Peters (31) lists a third subspecies, enigmaticus, from Kutch, India, as doubtfully distinct. Ripley (32) does not recognize enigmaticus and, following his classification, it is here considered as synonymous with koslovæ.

Order	Columbiformes
Suborder	Pterocletes
Family	Pterocledidae
Genus	<u>Pterocles</u>
Species	<u>P. orientalis</u>

### Subspecies

<u>P. o. orientalis</u> (a)	Imperial sandgrouse	Eastern Canary Islands, North Africa, Portugal, Spain, Cyprus, Turkey, Syria, Jordan, Iraq, and Saudi Arabia
<u>P. o. koslovæ</u> (b)		Southeastern Russia and southwestern Siberia from the lower Volga and the Caspian Sea east to Sergiopol, south to Alma Alta and Tashkent and southwards to Iran, Afghanistan, West Pakistan and northwestern India.

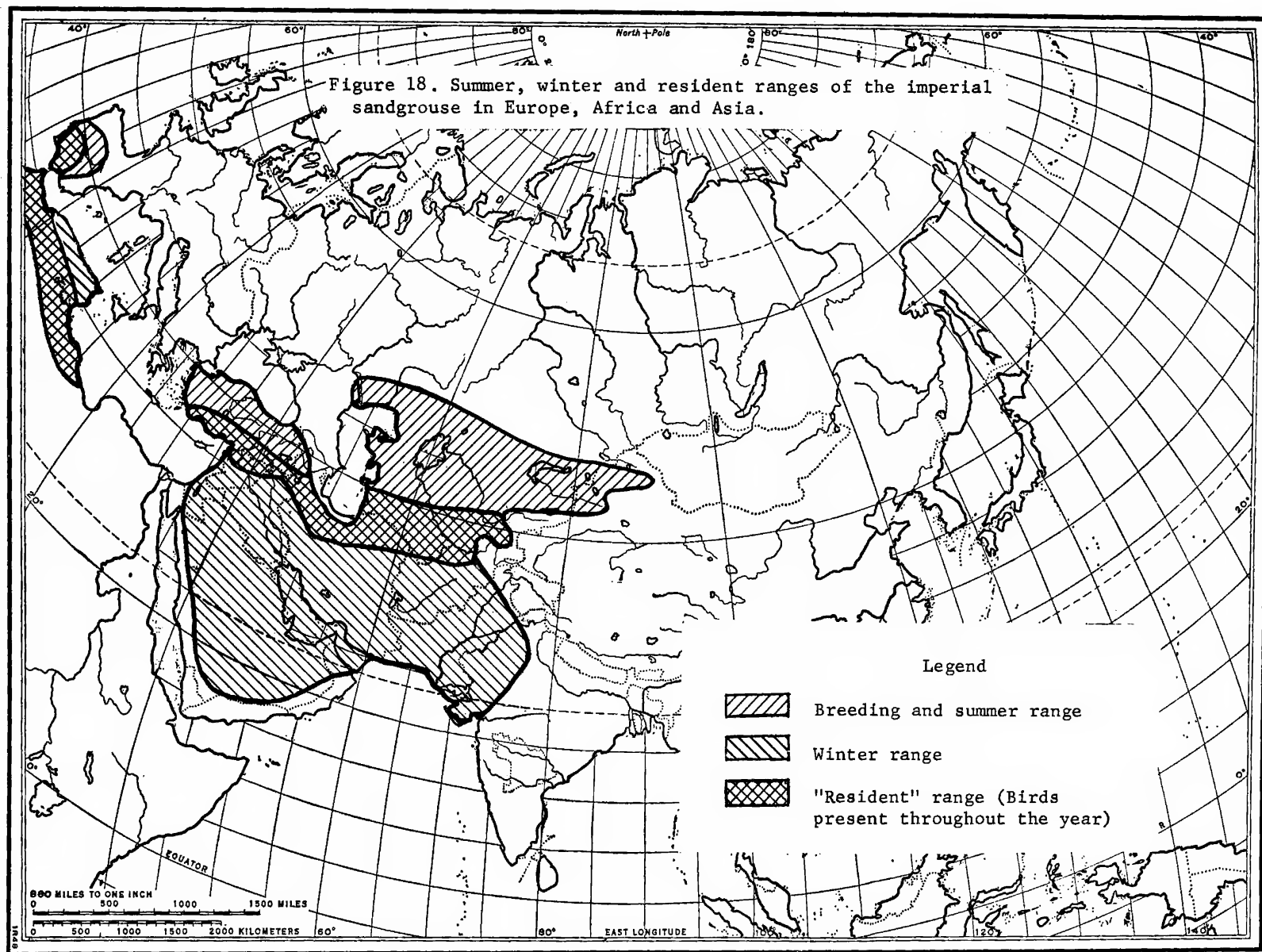
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(a) Earlier called P. arenarius (29)

(b) Dement'ev (15) calls this subspecies P. o. arenarius



Figure 18. Summer, winter and resident ranges of the imperial sandgrouse in Europe, Africa and Asia.



## Introductions

No attempts to introduce the imperial sandgrouse into new areas are recorded in the literature.

## Common Names

This sandgrouse is so widely distributed that many names have been applied to it. Among the most commonly used are the following: sandgrouse (Old English); imperial sandgrouse (English); black-bellied sandgrouse (English); oriental sandgrouse (English); large sandgrouse (English) Ortega, Corteza (Spanish); Cortical (Portugal); koudri (Moorish); ganga unibande (French); sandflughuhn (German); ringflyghona (Swedish); step tavugu (Greek); bartluk, bagertlak (Turkish, Turkey, Iraq, Iran); katarr, Gata (Arabic); gutta (Arabic, Iraq, Iran); siya-sinah (Iranian); chur, katinga (Sindi, West Pakistan); banchur, kurmor (Peshawari, West Pakistan); bhat-titur, bakht-titur (Hindi, India); boetoyhbin yephoopioxnprook (Russian); and Steppe-hen (Russian translation).

## Distribution and Abundance

The imperial sandgrouse is an inhabitant of the Mediterranean steppe, and desert climatic zones. The range of this species exhibits an interesting division into two widely divergent regions. Birds in the Iberian peninsula and northwestern Africa are separated by southern Europe, Libya, and Egypt from the main concentrations in the Middle East, southwestern Siberia, Afghanistan, West Pakistan, and northwestern India (fig. 18). This separation probably took place rather recently since taxonomists have found no basis sufficient to indicate that the birds of western Europe and North Africa differ from those occurring in the Middle East. The range, including this gap, extends some 5,500 miles east to west and 2,500 miles north to south.

Birds commonly winter in southern Spain, North Africa, the Middle East, southern Siberia, and the western part of the Indian subcontinent. Bump observed wintering birds in southern Spain, southern Turkey, northern Iraq, Iran south of the Elburz mountains, and in middle West Pakistan. Baker (3), Christensen (14), and Bohl found large concentrations of imperial sandgrouse in the northwestern part of the Thar or Sind desert of Rajasthan, India, from December through February. Whittaker (45) reported both resident and migratory imperials in northern Morocco, Algeria, and Tunisia, largely south of the coast ranges of the Atlas Mountains. Bodenheimer (5) observed imperials in the south Syrian desert, about the Dead Sea, and in the Negeb. Meinertzhagen (26) located them wintering in considerable numbers in the arid wastes of northern and eastern Saudi Arabia. Dement'ev (15) quotes Zarudney (1915) (a) as

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(a) All references where the author and date of publication, rather than the reference number, are given are taken from Dement'ev (15) and are mentioned here to facilitate further identification of the source since translations of the original references are not available to us.

indicating that large numbers remain in the Kizil-Kum desert in Kazakhstan during the warm winters and Ivanov (1940, 1945) found occasional birds in Tadzhikistan even after the majority had migrated to the south. Dement'ev states that they winter regularly along the Amu-Darya River, in the Murgab, in Tedzhen, and in the piedmont zone of Kopet-Dag, as well as along the eastern coast of the Caspian Sea.

With the advent of warming weather, wintering populations move northwards to their breeding and summer ranges in central and northern Spain, the arid, Anatolian region of central Turkey, the broad plains and valleys to the east, and the uplands of northern Iran. Some birds, presumably migrants from northwestern India and West Pakistan, move into the high plateaus of Afghanistan, where Bump found them breeding at about 10,000 feet in 1956. Further north, beyond the great massif of the Hindu Kush, we saw birds in June on the grassy airfield at Kunduz in Afghanistan on which they are reported to nest. Some even settle down on the steppes of southwestern Siberia north and east of the Caspian Sea (Dement'ev 15). So far as is known no imperial sandgrouse breed in India and I do not know of many in the highlands of the Northwest Frontier, though Williams (46) reports that large numbers nest in the valley about Quetta, West Pakistan, and in the low hills to the west. In studying and collecting foreign game species, Bump traversed most of the range of the imperial sandgrouse, except for Siberia, and Christensen and Bohl observed the birds mainly in northwestern India. For clarity, first-person singular references, used here, refer to observations by Bump.

Apparently nonmigratory populations have established themselves in Spain, North Africa, southern Turkey, and northern Iran. Dement'ev (15) indicates that probably sedentary birds are found still further north in Turkman and Tadzhikistan north of Iran and Afghanistan as well as in northern Iran, and Dolgushin (17) states that some imperials winter, when conditions are favorable, as far north as Kazahkan, east of the Caspian and Ariel seas.

The general impression of vast numbers of imperial sandgrouse in favorable habitats has developed from concentrations observed about waterholes in the early part of the day. In arid areas, open water attracts these birds from all the surrounding territory and, on occasion, from distances as far as 10 to 20 miles away. Their thirst quenched, they then scatter out to the extent that from April through October I found it difficult to locate more than pairs or small parties of birds together during the remaining hours of daylight.

No extensive studies of breeding density have been undertaken. In Anatolia, judging from the number of adults frequenting an isolated waterhole in relation to the extent of potentially productive habitat surrounding it, I estimated that breeding populations here might be from 1 to 2 pairs per 100 acres. One might be casually surprised at

such a low density unless he correlates it with habitat so dry and arid in character that in some areas only sandgrouse and bustards, among the game birds, are capable of survival therein. For the area about the Zeravshan River near Samarkand, Siberia, Dement'ev (15) quotes Dal as reporting densities of one bird per 7½ acres on arid clay soil, one to 20 acres in rocky semi-desert tracts and one to 250 acres on steppes sparsely covered with feathergrass (Stipa sp.).

Description

The plumage of all sandgrouse harmonizes so well with the arid lands which they inhabit that the birds are often rather difficult to detect. As with several other Asian species, the general color for both sexes of imperial sandgrouse is a blending of buff-gray, brown, black, and yellow ochre. On close inspection, the large size, coupled with the dark brown to black abdomen, the pointed but not distinctly elongated tail, the wings, white on the underside but with black tips, and the pale chestnut collar around the neck of the male are identifying characteristics of the imperial sandgrouse.



Figure 19. Imperial sandgrouse, wild-trapped in Turkey  
Female  
Male Female  
Female Male

Stuart Baker (3) provides the following detailed description of adult males and females:

#### Adult Male

"Head above, neck and upper back grey tinged with russet; purer grey around the eye; back, rump and upper tail-coverts grey, the latter blackish, each feather pale buff at the base and with a large drop of deeper buff at the end; tail-coverts edged with yellow; inner wing-coverts and scapulars like the back but with the spots larger and yellow-ochre in colour; secondary and median coverts yellow-ochre; bastard-wing grey; outer web of first primary brownish-black; remaining primaries and secondaries white on the basal half and greyish-brown on the terminal with a few curious streaks of brown on either web; central tail-feathers barred grey and buff, tipped with grey-green edged with a narrow line of buff; remaining tail feathers the same but with a broad terminal line of white and each feather deepening in colour until the outermost are dark grey, merely stippled with rufous at the base; chin, upper throat, sides of head and neck chestnut, extending as a collar around the neck except in the centre, where it pales first into orange and then into the grey of the neck; a triangular patch of black on the lower throat, sometimes extending up the sides of the neck; breast grey, followed by a black band extending up the sides of the shoulders; a broad belt of vinous or pinkish, grey follows the black; abdomen, flanks, upper thighs and vent chocolate-brown or blackish, the rusty bases to the feathers sometimes showing through; lower tail-coverts, lower thighs and feathering of tarsus white."

#### Adult Female

"Whole upper plumage pinkish-grey, the head, nape and upper back with black streaks, the remainder more rufous and barred; central tail-feathers like the back, each succeeding pair darker and with broad terminal bars of white; scapulars and inner wing-coverts like the back; quills like those of the male but browner and with the tips and edges of inner webs of the primaries white; primary coverts grey; secondary coverts dark grey, median coverts yellow-ochre on the visible portions, chin, throat and sides of head yellowish-grey, the sides of the head, lores and ear-coverts finely streaked with black; lower throat with reversed half-moonshaped band of black, followed by a pearl-grey band fading into pinkish-grey on the breast; remainder of lower parts as in the male."

"Colours of soft parts, iris brown, edge of eyelids lemon-colour; bill pale to darkish plumbeous, tip blacker; legs and feet grey, tinged brown, earthy, or plumbeous, claws darker."

### Juvenile Male

"Young male shot in October has the whole upper plumage, chin, throat, breast and upper abdomen a pale isabelline, barred and vermiculated with blackish-brown; abdomen black and under tail-coverts white with black bases; tail-feathers barred black and rufous-buff, black and white on the outermost; wing-quills and primary coverts grey, tipped with rufous."

### Size and Weight

The imperial sandgrouse is the largest of its genus. Baker (3) records its length as between 13.7 and 15.7 inches with a wing measuring between 8.8 and 9.7 inches. Adult males on the average will weigh from 1 pound to 1 pound 4 ounces, while females are slightly smaller.

### Habitat and Cover Preferences

#### Cover

Sandgrouse, as well as the bustards, are birds typical of arid steppes and desert wastes. The imperial sandgrouse also finds to its liking extensive areas of scattered grass and weeds, dry-farmed lands where the crop is open or sparse, fallow or stubble fields, and dusty patches of desert roads or trails. Also favored are moderately to heavily grazed arid ranges. Dense cover and forested tracts are avoided.

In its breeding range in Spain, Turkey, and Iran, the imperial associates with desert habitats and with arid areas in which some dry farming is present. The semidesert steppes of the Anatolian plain in Turkey is a vast, dry region, covered sparsely with desert weeds, grass, and occasional shrubs or trees about the infrequent watering places. Brief winter and spring rains encourage some straggling attempts to grow wheat or barley and imperial sandgrouse are there in great abundance. Further east, where annual precipitations range between 15 and 27 inches, but summer and fall are still very dry, the Turks have plowed up large areas of grazing lands and converted them to winter wheat. While we drove about these farms, imperials were frequently found along the bare shoulders of the road or settled comfortably in the deep dust between the wheel tracks. From fields sparsely covered with weeds and stubble, about 25 birds were flushed in 2 miles of travel with the jeep (8).

Further east, in north central Iran, large numbers of these birds were observed in the fall on vast alkaline flats, quite bare of vegetation in parts but covered here and there with patches of spiny weeds, clumps of grass, and occasional low shrubs. The nearest cultivation was about 6 miles away. Considerably to the east of this area lay flat, dry steppes interspersed with barren salt or alkaline deserts. On the steppes there was some dry farming with wheat the principal crop raised. Vast areas were unscratched by the plow. Sheep and goats grazed fitfully among the scattering of thorny shrubs, perennial weeds, and some grass. Water was scarce and often salty. Here also were many imperial sandgrouse along with the great bustard (Otis tarda) the Hubara (Chlamydotis undulata macqueenii), gazelles, and desert foxes (7).

As previously indicated Bohl and I saw these sandgrouse on the hard-baked airfield at Kunduz in northern Afghanistan and were told that imperials commonly nested either on or in the immediate vicinity of the field. Further south, on a high plateau extending out from the peaks of the Hindu Kush near Band-i-mer I flushed a brood consisting of 2 adults and 3 young from a short-grass meadow in early July. Fortunately I was able to collect one of the chicks which appeared to be about one-third grown and so small as to indicate the probability that imperial sandgrouse utilize these uplands as nesting and summer ranges. Dement'ev (15) also indicates that imperials take readily to upland plateaus and in Tarbagata and especially in central Tyan-Shan they are common on high mountain steppes.

No attempt to identify the plants characteristic of summer imperial range was made by Program personnel. Zohary (47) indicates Sueada vermiculata, Atriplex sp., Schangenia bascata, Alhagi maurorum, and Juncus maritimus to be present on steppe and alkaline flats in Iraq and Iran. On gypseous soils Cleome glauca, Verbascum damascenum, Achillea sp. and Moltkia angustifolia are common. Within the breeding range in northern Iran, Iraq, Turkey, and southern Siberia, Zohary lists Artemesia herba ssp., Achillea santolina, Poa sp., Salsola rigida ssp., Andropogon sp., Capparis sicula, and Carex sp., some of which are familiar to game personnel in the western United States. In addition, other shrub and forb species include Salvia sp., Scrophularia xanthoglossa, Gypsophila pallida, and Althaea rufescens.

Vegetation from dryland farm fields includes the genera of Lolium, Poa, Helicophyllum, Medicago, Vicia, Euphorbia, Convolvulus, and Salvia. In irrigated fields in these arid areas are found such familiar plant genera as Prosopis, Andropogon, Echinochloa, Portulaca, Amaranthus and Rumex.

Wintering grounds do not appear to differ materially from breeding ranges. In fact, in Spain, Turkey, and Iran it was not unusual to find some birds the year around in the warmer sections of the imperial's range. Whittaker (45) describes Tunisian wintering areas as semidesert plains in which sandy hillocks, strewn with stones and dotted with patches of Halfa-grass, are characteristic features.



Figure 20. Imperial sandgrouse habitat in central Spain

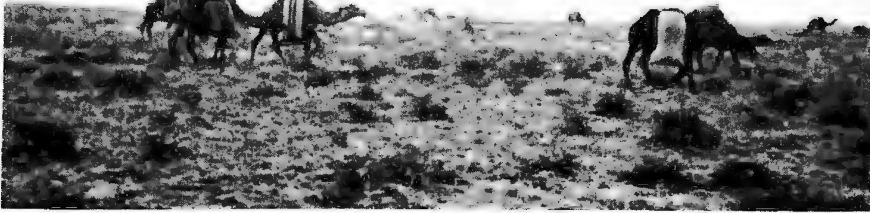


Figure 21. The Anatolian region of Turkey attracts many imperials



Figure 22. Some birds gather on winter wheat or scattered grass in early March





Figure 23. Typical imperial habitat in south-central Turkey



Figure 24. Many birds were located in the steppes of north-central Iran



Figure 25 Upland valleys and plateaus attract nesting imperials in Afghanistan

There are many semiarid habitats in the western United States that appear to be similar to those characteristic of the native range of the imperial sandgrouse. A few are pictured here.



Figure 26. Northern Great Basin farming areas represent potential breeding and nesting grounds for imperial sandgrouse



Figure 27. A combination of scattered grassy tracts with dryland farming might provide excellent spring and summer habitat



Figure 28. Great Basin habitat with sagebrush, grass and saltbrush



Figure 29. Brush is not too dense here to preclude use by sandgrouse



Figure 30. Wintering areas, as bare as the Mojave Desert, support imperials in Asia

In southern Iran, Iraq, Syria, and Turkey, where birds wintered, annuals found include Plantago ovata, Schismus sp.; Astragalus spp. Medicago laciniata, and Stipa tortilis (Zohary 47). In sandy deserts of southern Iraq, Zohary notes typical plants as Haloxylon salicornicum, Rhanterium epapposum, Teucrium sp., Heliotropium persicum, and Lithospermum callosum with Zizyphus nummularia.

A major wintering area for imperial sandgrouse is the Sind or Thar desert of Rajasthan, India. Christensen (14), who was a Program collaborator in this area from 1959 to 1961, describes the range of major concentration as follows:

"The Thar Desert is a sandy grassland plain with the vegetational makeup of the habitat dominated by an overstory of scattered mesquite (Prosopis specigera) and an understory of large spiny shrubs composed principally of Capparis aphylla, Zizyphus sp., Acacia leucophloea, Rhus mysorensis, and Euphorbia royleana. There are frequent expanses of bare ground; however, during years of good precipitation the desert floor is covered with a turf of forbs and grasses. Some of the more common forbs are Calotropis sp., Aeura javanica, Indigofera sp., and Tephrosia sp. Grasses are very well represented with some of the most prominent ones being Elionurus hirsutus, Cenchrus sp., Heteropogon contortus, Gracilea royleana, Eragrostis major, Aristida sp., Cynodon dactylon, and Sporobolus pallidus.

"Checkerboarding the Thar Desert are small patches of cultivation which depend almost entirely upon monsoon rains for success. The principal crops are millet (Pennisetum typhoideum), sorghum (Sorghum sp.), pulse (Phaseolus sp.), and wheat (Triticum sp.). Towards the western reaches of the desert, where the annual rainfall is between 5 and 10 inches the amount of cultivation is reduced considerably."

### Topography

Topographically speaking, imperial sandgrouse habitat is characterized by flat to rolling country. This may take the form of seemingly endless steppes, broad valleys bounded by hills or mountains, or extensive mesas and upland plateaus. Low hills pose no impediment to movement even in summer. In fact I occasionally flushed these sandgrouse from moderately steep hillsides about waterholes though such topography must be considered as incidental to sandgrouse habitat. Though occupied steppes are basically flat, the land surface is often broken by hummocks hillocks, minor eroded areas, or occasional worn-down rocky outcrops.

In contrast with topography, elevation plays a minor part in habitat selection. Birds occur in the summer range from almost sea level to above 10,000 feet. The major breeding areas in Spain, Turkey, Iraq, and southern Siberia lie between 1,000 and 4,000 feet in elevation; wintering grounds are lower in the Middle East, West Pakistan, and India.

## Soils

Sandy, loamy, clay, or gravelly to stony soils are the rule in imperial habitat. Rough, rocky surfaces are avoided. Saline or alkaline flats, largely bare in character but with scattered patches of vegetation were attractive to many birds. In Siberia, Dement'ev (15) mentions gravelly to sandy soils in the foothills and clay, overgrown with open salt marsh vegetation east of the Caspian Sea as being suitable for sandgrouse.

## Climate

Sandgrouse of the genus Pterocles, for the most part, prefer warm to hot, arid habitats. The imperial is, to some extent, an exception in that it also thrives under somewhat cooler and less arid conditions than do other members of this group. Many sandgrouse roam widely, but the imperial, while resident in some areas, has adapted itself to a wider range and a greater variety of climatic conditions, than most, because of its semimigratory habit.

### Of the summer range

The breeding and summer range for the imperial sandgrouse lies roughly between the July isotherms of 70° and 80°F. in Spain and north Africa and between 75° and 85°F. in Asia. In this range the average maximum temperatures for July are normally from 85° to 100°F. with several stations recording from 110° to 114°F. Average minimum temperatures in July run for the most part from 56° to 73°F., with a low of 43°F. in Siberia and a high of 76°F. in Afghanistan.

In central Turkey, nesting commences at average maximum temperatures of 50° to 64°F. and average minimum temperatures of 35° to 40°F. Similar temperatures on the breeding grounds in North Africa are slightly higher. In both areas nests have been reported as early as mid-April and in central Turkey I located a nest with eggs in late August near Konya where average maximum temperatures were 86°F., and average minimum temperatures were 58°F. Nesting in southern Siberia begins in early to mid-May in the lowlands about the Syr-Darya River (15). Average maximum and minimum temperatures for May in this region are 92° and 40°F. Further east nesting commences 3 weeks to a month later, when temperatures approximate those of the Syr-Darya region for May. Average monthly temperatures for stations within the breeding range of the imperial sandgrouse are presented in table 6.

The pattern of precipitation throughout the breeding and summer range is one of very moderate to fairly high rainfall in March and April and, in some parts, well into May. June through September is generally very dry with a modest to substantial increase in precipitation throughout the fall. Annual precipitation within the summer range is usually 10 to 15 inches, but several stations record less than 5 inches and a few above 20 inches.

Snow is uncommon on the breeding grounds, though on several occasions in March in north-central Turkey I observed small flocks of imperials while light snow from a late storm covered the ground. In the same area a few sandgrouse were normally to be found throughout the winter in the face of occasional snowfalls that might last from 2 to 4 days. Dement'ev (15) also mentions Khomyakov (1901) as noting flocks of imperials during a snowstorm in late autumn near Ryazan. With the advent of the first small snowfall, usually in late October or November, most of the birds moved southwards.

#### Of the winter range

The wintering grounds of the imperial sandgrouse lie between the January isotherms of 40° and 65°F. in Asia and 50° and 65°F. in North Africa and the Iberian Peninsula. The regions of largest winter concentrations are between the 50° and 60°F. isotherms. Average maximum temperatures for January are mainly from 50° to 70°F. with a low of 39°F. in south central Turkey and a high of 84°F. in Saudi Arabia. Average minimum temperatures for January lie mainly between 23° and 50°F. with a low average minimum of -3°F. at Tashkent (Siberia) from which area considerable numbers of these birds are reported on warm winters (15).

Most imperials arrive on their wintering areas in November, when average maximum temperatures are from 50° to 85°F. and average minimums from 33° to 55°F. Birds usually leave the wintering grounds in late February or early March when average maximum temperatures are from 60° to 85°F., and average minimums from 30° to 55°F. Temperature data for 49 stations representative of winter range are presented in table 6 .

Precipitation within the winter range of the imperials is normally between 10 and 20 inches a year, though as low as 3.2 inches in Saudi Arabia and as high as 33 inches in northwestern India. Two patterns of winter precipitation are evident. In Spain, North Africa, the Middle East, and southwestern Siberia the major part of the precipitation for the year comes in winter. This situation is reversed in India and West Pakistan. The amount annually received from November through February varies from 0.79 inches at Bikaner, India, and 1.1 inches in Saudi Arabia to 16.4 inches at Mardin, Turkey. Snow is unknown over most of the wintering range, though it occasionally occurs for brief periods in southwestern Siberia, in southern Turkey and in Spain.

#### Of the "resident" range

Since few if any imperial sandgrouse have been banded and retaken, one cannot state with certainty that they are resident throughout the year in any part of their range. As previously noted, many authors have indicated these birds to be resident in a long narrow belt stretching from Spain and North Africa to southwestern Siberia (fig.18). The basis for this judgment has been the presence of these birds throughout the year. As mentioned elsewhere, this is by no means an infallible indicator of residency. Resident is here used to define the areas in which imperials are found both winter and summer.

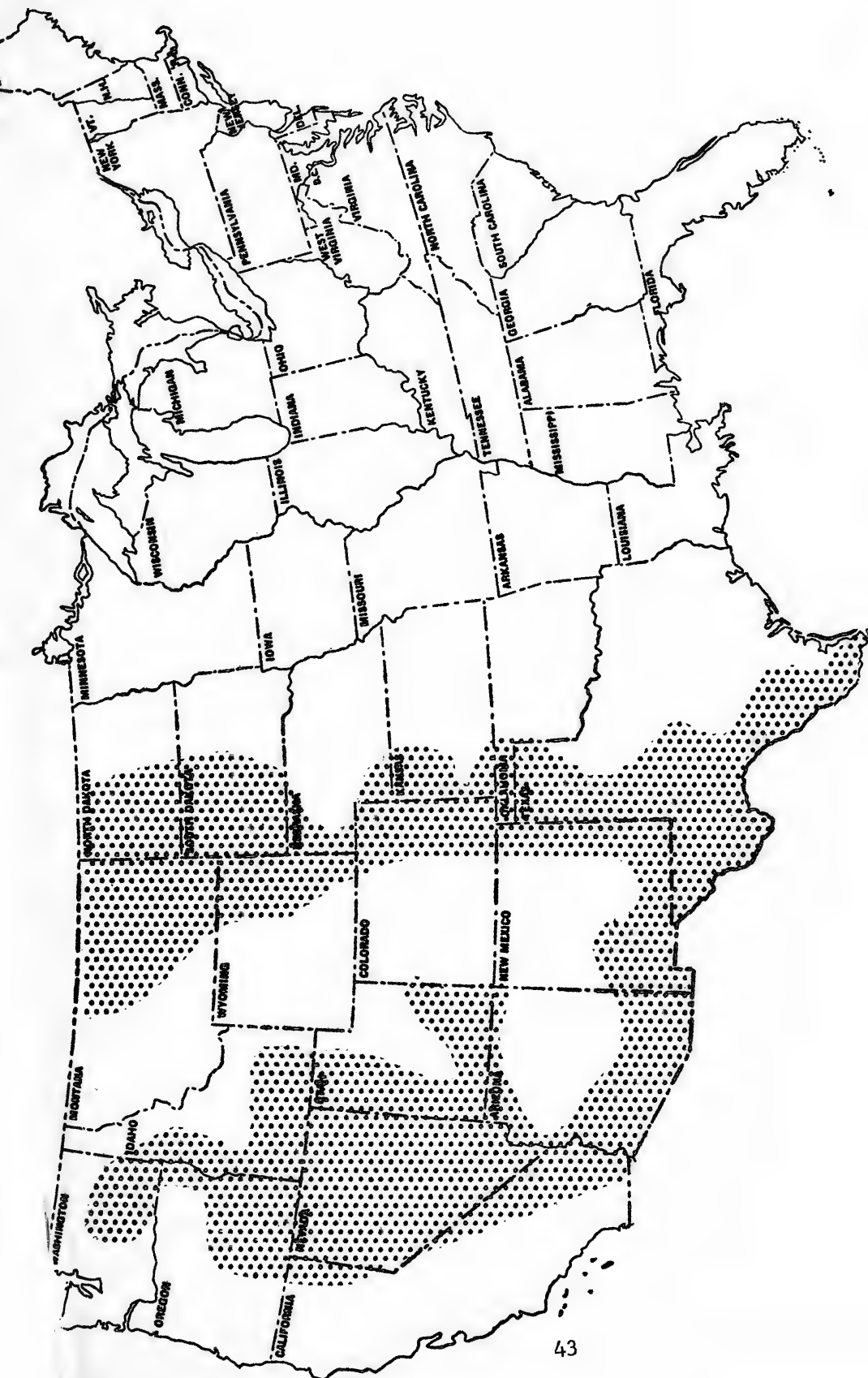
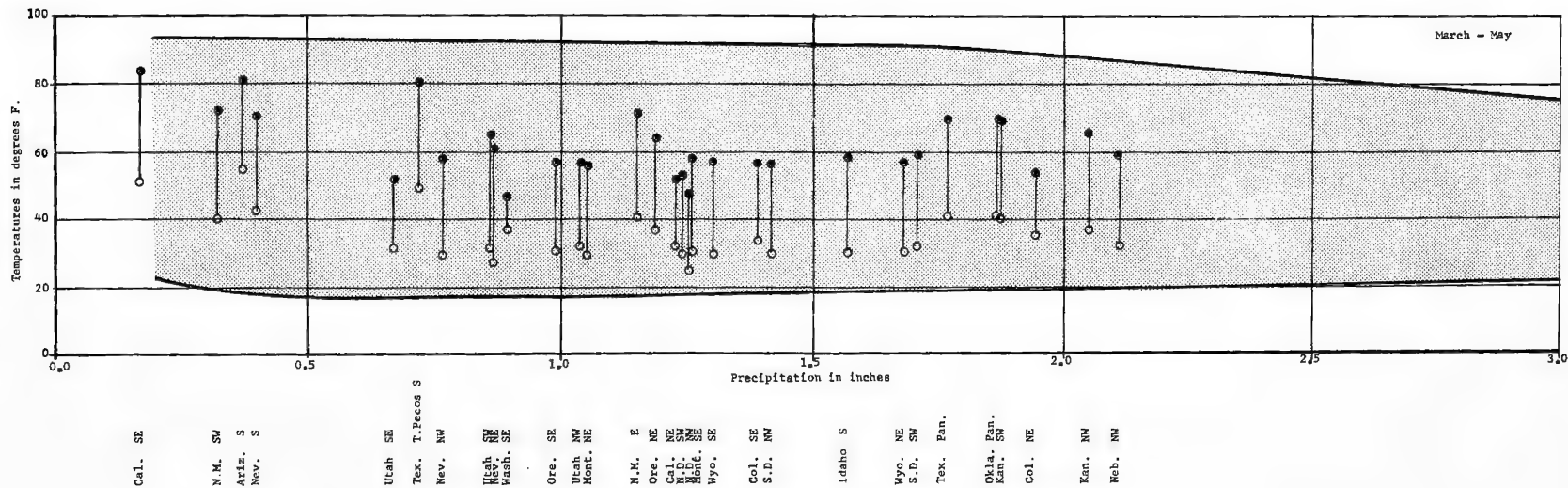
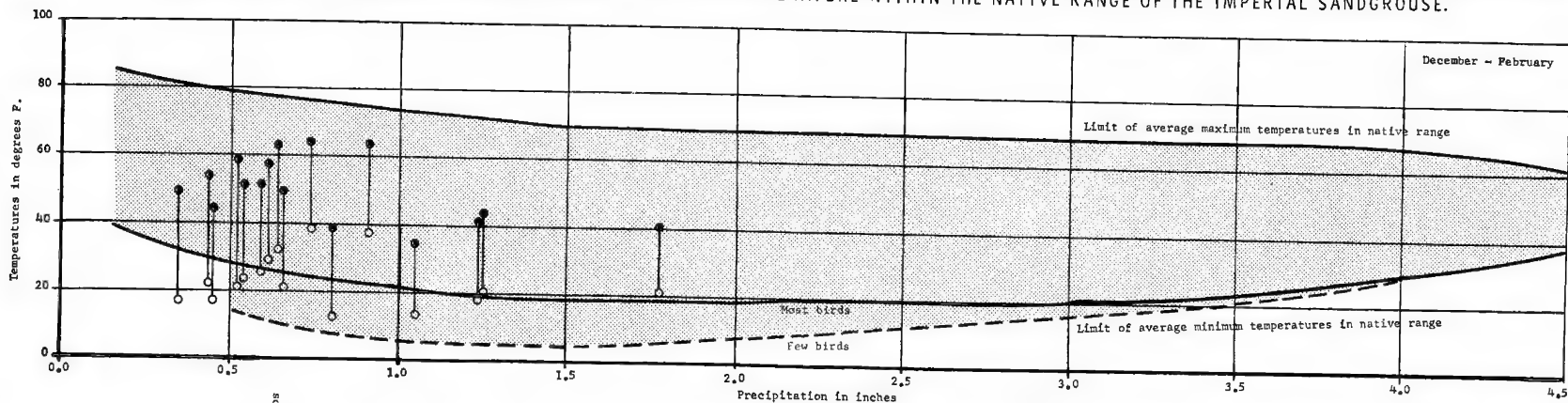


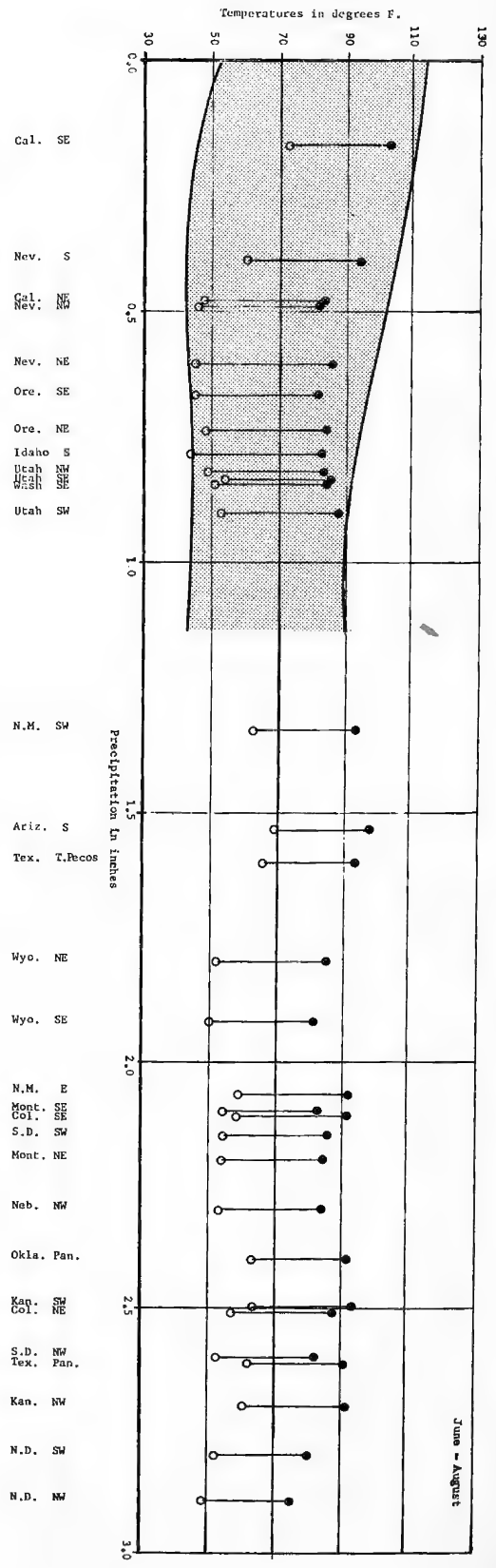
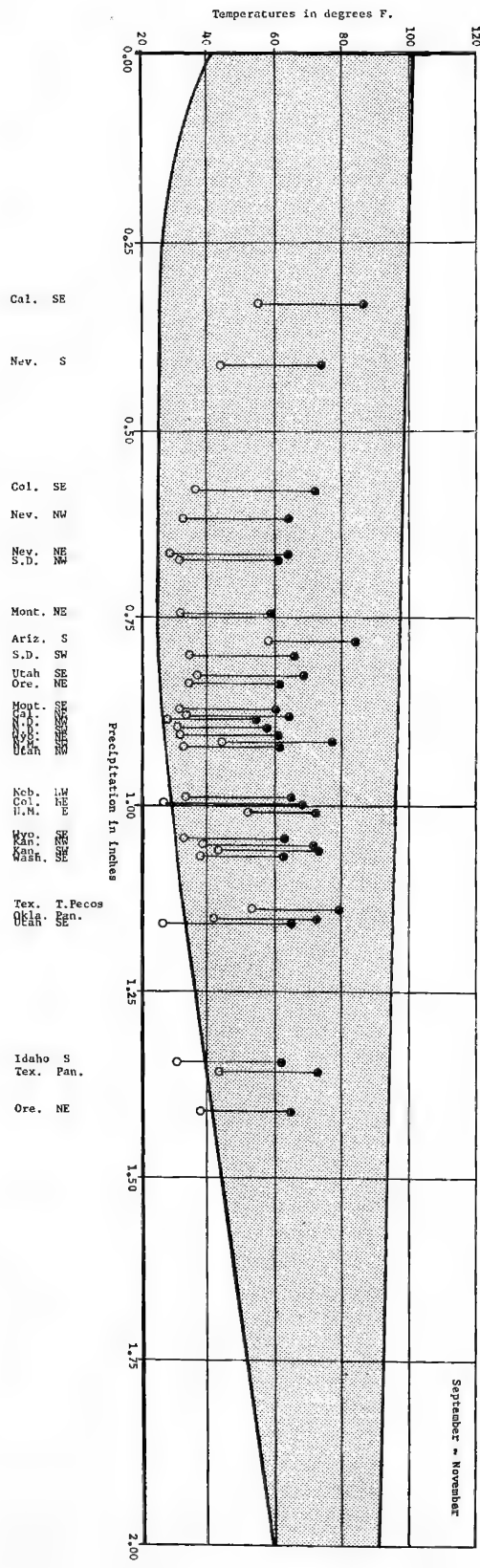
Figure 31. Areas in the United States which are similar in climate and topography to imperial sandgrouse breeding and winter ranges in portions of North Africa, Southern Europe and Asia.



FIGURE 32. AVERAGE MAXIMUM AND AVERAGE MINIMUM TEMPERATURES IN RELATION TO PRECIPITATION BY SEASONS FOR POINTS IN THE UNITED STATES COMPARED WITH SIMILAR UPPER AND LOWER LIMITS OF TEMPERATURE WITHIN THE NATIVE RANGE OF THE IMPERIAL SANDGROUSE.







Isotherms for January and July do not correlate well with the areas in which this sandgrouse is resident. As is to be expected, average maximum and average minimum temperatures tend to fall above those for more northern summer ranges and below those for prime wintering grounds in Asia. Imperials are resident in North Africa where average minimums are as low as 19°F. In southern and southeastern Turkey, the highest January average is 65°F., the lowest 23°F. Resident range in southwestern Siberia is colder, with the highest January average 60°F., the lowest -3°F. July average maximum and minimum temperatures for North Africa resident range reach 113°F. and 49°F.; similar figures for Turkey are 99° and 58°F., and for Siberia are 106° and 54°F. Most of the stations for which temperature and precipitation data are recorded fall well short of these extremes (table 6).

Yearly precipitation follows the patterns indicated above for summer and winter ranges. Total precipitation for the year may be as low as 2 inches in Tunisia and as high as 27.6 inches in eastern Turkey with many stations having a total between 6 and 15 inches. (See table 7.)

### Climatic comparisons

Both climate and habitat within the range of the imperial sandgrouse exhibit many similarities in general with parts of the semiarid western United States. Included are short-grass habitats along the Great Plains from western North Dakota south to Texas and the region from the Columbia Plateau south through the Great Basin to the Mohave Desert and to southern Arizona and New Mexico. The more northern areas and the higher plateaus along the Rockies represent potential breeding and summer range, while winter habitats might include the more southern, warmer areas. In addition to semiarid rangelands, fields of wheat and other cultivated grains should prove attractive following the harvest. In figure 31 is a map of the United States outlining areas which by climate and topography might be suitable for trial introduction of imperial sandgrouse.

For those who wish to make a more exact comparison of temperature and precipitation within the native range of the imperial, with climatic conditions existing locally, climacurves are presented in figure 32. These comparisons indicate the average maximum and average minimum temperatures in relation to precipitation for the breeding and the winter ranges of the imperial sandgrouse. Smoothed curves for each period represent the upper limits of the average maximum temperatures and the lower limits of the average minimum temperatures in relation to precipitation. The breeding period here represented is April through July. November through February is the period normally spent on the winter range. By plotting on these graphs similar climatic data for any given locality being considered for the trial introduction of imperial sandgrouse, one can make the desired comparisons of climate at a glance.

## Food and Water

To find food and water in the apparently inhospitable arid to desert ranges of southern Asia presents problems beyond the resources of most birds. Only those species that can forage over wide areas and flourish on a relatively limited array of plant and/or animal materials, can survive. Among game birds only bustards and the sandgrouse have become adapted, through the ages, to habitats where precipitation is often only 3 to 6 inches a year. Sandgrouse have solved the problem of finding food and water in desert regions through their ability to subsist largely on grass and weed seeds, sometimes much smaller than the head of a pin, and to fly long distances to water.

Sandgrouse are often satisfied to laboriously glean the smallest seeds, usually reserved for birds of much lesser size. Wemshurst (27) found about 30,000 tiny seeds of clover (Melilotus sp.) and of vetch (Astragalus sp.) in one bird collected in Iraq or Iran. The imperial sandgrouse as an additional adaptation, utilizes large seeds, including waste grains to a much greater extent than do most Asian sandgrouse.

Baker (3) indicates that "the food is mainly seeds and grain with some leaves and young shoots and buds -- but they will also eat insects of many kinds - white ants, beetles, larvae, etc." Dement'ev (15) gives the food as "seeds and shoots of steppe and desert plants, sagebrush (Artemesia spp.), Russian thistles (Salsala spp.), camel thorn (Alhagi camelorum) etc., and insects in small numbers."

No detailed study of food consumed seasonally has been made. I collected a number of birds in Turkey between 1950 and 1953 but adequate facilities for identifying to genera and species the foods eaten, were not then available. Twenty imperials were shot at a waterhole, surrounded by cultivation, on July 29 west of Konya, Turkey. Of these birds, 13 had eaten only weed seeds, 4 crops contained weed seeds and wheat or cultivated legumes, and 3 were empty. Most of the birds had also taken grit in the form of a few small stones. No green food or insects were present, although on two occasions birds collected in April had eaten what appeared to be green shoots of wheat. Three birds collected in May near Tuz Gölü, a large salt lake south of Ankara, contained only weed seeds.

Of two birds shot southwest of Teheran, Iran, on October 26, 1950, one had dined entirely on the curled tips of an unidentified desert plant, the other contained about 70 percent of weed seeds and 30 percent of wheat.

There was general agreement among agriculturalists in Turkey that the wheat eaten by imperial sandgrouse was waste grain remaining on the ground after the spring harvest and that the bird did no damage to agricultural crops. This is in distinct contrast to the pin-tailed sandgrouse (P. alchata) which gather in enormous flocks. In Iraq I watched several such packs moving across a farmer's primitively seeded field, like a swarm of locusts, consuming as much of the freshly planted wheat as they could find.



Figure 33. The pin-tailed sandgrouse in Iraq often travel in enormous flocks

The imperial sandgrouse is much less addicted to feeding in wheat or barley stubble or planted fields, seemingly preferring the rough fare of the desert to the cultivated grains shaken loose by the scythes of the peasants. In addition imperials usually feed in pairs or in small flocks of 3 to 25 birds except on their wintering grounds where larger flocks are sometimes encountered.

During the winter of 1959-60, Christensen (14) examined the food taken by 13 imperial sandgrouse collected in the eastern part of the Sind or Thar desert of Rajasthan, India. Table 5 lists the results in terms of items eaten, frequency of occurrence, and percentage of total volume. He concluded that "The Imperial is primarily a seed eater during the period of the year represented. Indigofera linifolia and I. cordifolia seeds, which are extremely small and consumed in enormous quantity, are a favorite food based on frequency of occurrence and total volume. The crop of one bird contained an estimated 8,700 Indigofera sp. seeds. Other food items are found less frequently, but due to the larger seed size, items such as Phaseolus aconitifolius, P. radiatus, Panicum sp. and Tephrosia purpurea make up a substantial part of the bird's diet. No insect material was consumed and, of the seeds eaten, three species were of cultivated crops. The pulses (Phaseolus sp.) accounted for 39% of the total volume. It is apparent that the Imperial utilizes waste grain from the fallow fields and is equally adept at taking advantage of the seed crop produced by native forbs and annuals."

Table 5. Food items eaten by 13 imperial sandgrouse collected at Pokaran, Phalodi and Patodi, India

Food	Parts eaten	Frequency of occurrence		Percent of total volume
		Number	Percent	
(a) <u>Indigofera linifolia</u> and <u>I. cordifolia</u>	seed	12	92	21
(b) <u>Phaseolus radiatus</u>	seed	4	30	16
<u>Panicum</u> sp.	seed			
	leaf	4	30	16
<u>Heliotropium strigosum</u>	seed	4	30	2.4
(b) <u>Phaseolus aconitifolius</u>	seed	3	23	23
Unknown seed No. 1	seed	3	23	T
<u>Tephrosia purpurea</u>	seed	2	15	12.6
(b) <u>Cyamopsis psoralioides</u>	seed	2	15	4.8
<u>Gynandropsis gynandra</u>	seed	2	15	1.2
Unknown seed No. 1	seed	1	8	1.2
Grit		9	69	1.2

- (a) These species not separated owing to their small size and the enormous quantities consumed.  
 (b) Cultivated grains.

Imperial sandgrouse are notorious travelers to and from the places where water is available for drinking. Local inhabitants in Turkey, Iran, and Pakistan report that the birds will fly 15 to 20 miles from resting and feeding places to water and return, once and occasionally twice a day. These birds favor particular watering places to which they come back day after day when not unduly disturbed. Such spots are mainly clear of vegetation, for they shun a brush- or grass-bordered place to drink unless the vegetation has been eaten or trampled down almost to oblivion, usually by sheep or goats. Flocks coming to water, wheel around such sites once or twice before pitching in steeply to alight a short distance from the water if no danger threatens. After a moment to as long as half an hour, they shuffle on short legs down the gentle slopes to the water's edge, to enjoy an unhurried drink. They often wade belly-deep into the water before drinking. Sandgrouse and pigeons are unique in that they immerse their bills and actually suck up the water without the necessity of raising their heads between swallows.



Figure 34. A lone imperial circles over a waterhole in Turkey



Figure 35. Large flocks commonly come for water in winter to the desert pond or tank at Bikaner, northwestern India

If hard-pressed, however, imperials will sometimes alight in the open water, drink, and depart. If frequently disturbed, as often happened in trapping or shooting at waterholes, the birds are apt to rise, circle several times, then seek out another place to drink. In Turkey the mere setting of inconspicuous nets in a location frequented by at least 200 sandgrouse caused all but a few stragglers to forsake the spot for other water by the end of the third day.

The regularity with which most sandgrouse, including imperial, come to drink often causes comment. In July, in central Turkey, one could set his watch at 8 a.m. by the arrival of the first birds. By 10 a.m. the last bird had departed.

Birds coming to water from a stream edged by fields of wheat, seldom stopped to eat and refused completely to touch grain scattered in and about the traps set to catch them at the water's edge. Their thirst sated, they rise, en masse or in small groups, to disappear over the horizon.

Tremendous concentrations of birds may be found about water in India (3, 14) and less frequently in Saudi Arabia (26) in winter. These are an aggregate of many small flocks which have joined forces enroute. Christensen (14) contributes the following observations on the water-drinking habits of the imperial sandgrouse at the famous Gajner tank (pond) near Rikaner, India. "I observed that the Imperial takes water early, coming to the tank just shortly after sun-up and prior to the Common Sand Grouse which follows it to water. Before watering, the birds assemble, sometimes by the thousands, on dry barren flats near the tank. Once the flock has accumulated, they will arise en masse and begin to circle the tank. If not disturbed, for these birds are much more wary than the Common Sand Grouse, they will land, water, and fly off to their feeding grounds. During the winter of 1959, I witnessed the fantastic sight of an estimated 8,000 Imperials watering at the Gajner tank near Bikaner, India." A portion of the imperial sandgrouse observed by Christensen at the Gajner tank is shown in figure 35.

In summer in Turkey, flocks of a few to 50 birds could be seen continually winging in to water, drinking, and after departure, breaking up into smaller groups in the far distance. Even in winter there is no counterpart to the massive Indian flocks that we observed in India.

Various species of sandgrouse congregate at watering places with no apparent difficulties. Christensen mentions imperials and common Indian sandgrouse drinking together at the same tank. At Ceylan Pinar (Antelope Springs) west of Mardin, Turkey, in December, I watched small flocks of imperials sandwiched in among a pack of at least 50,000 pintailed sandgrouse wheeling and circling over the water, pausing to drink then again joining the milling, airborne thousands in a scene of unforgettable confusion.

That even with the far ranging imperials, the lack of available water can limit distribution is indicated by Dement'ev (15) who states that in the extensive, waterless tracts within the Kara-Kum and the Kizil-Kum deserts, these birds do not occur.

The question how water is supplied to the young at the nest has been raised but never adequately answered. Mead-Waldo (1922) believes that the parent birds soak their breast feathers when they drink and thus carry water to the young. Meinertzhagen (26) indicates that young common Indian sandgrouse, reared in captivity, were supplied by the regurgitation of water from the crop of the parents. Dement'ev agrees with this and quotes Nazarov (1886) as indicating that as much as a "cupful" of water has been found in the crops of imperials shot about waterholes.

### General Habits

#### Migrations, Movements and Mobility

Imperial sandgrouse are inclined to wander less locally than do many other sandgrouse. In most regions they are semimigratory, but some areas hold birds throughout the year. Arevalo and Baca (1), referring to Spanish birds, considered them to be generally sedentary, and Whitaker (45) describes them as "distinctly a resident species" in North Africa. I found imperials present, even in winter, near Konya and Palatali, in the arid Anatolian plains of southern Turkey, but in the absence of banded individuals it was not possible to determine whether these were birds raised in the vicinity or were migrants from further north replacing southward moving local stock. Even in the northern part of their range in Asia Minor it was not unusual to find an occasional bird throughout the winter.

Late fall is the time of southward migration in central Turkey with the birds returning in March. Dement'ev (15) states that imperials start gathering in larger flocks in August and September and begin their southward movement about a month later. Christensen (14) dated the arrival of imperials in northwestern India as November; their departure as occurring in late February or early March. Correlating these movements with temperature he indicates, "The arrival and departure dates of the imperial fit well into the expressed temperature pattern. From the monthly mean temperatures it can be seen that the birds arrive at the beginning of the winter period when the average monthly temperatures have dropped to approximately 70°F. The birds remain through the months of November, December and January and in late February and early March, as the mean monthly temperatures start to exceed the 70°F. mark, the birds leave. There would seem to be little doubt that the timing of the arrival and departure of the Imperial Sand Grouse into north-western India is influenced considerably by temperature."



In Kuwait which is considerably warmer from November through April than is Rajasthan, Dickson (16) reports imperials as arriving between September 15 and October 15 and leaving for the north between April 10 and 30. Ingoldby (27) reports imperials at Quazvin, west of Teheran, Iran, in early February and I collected a pair near Shahrud in early April. In fact, arrival dates on breeding grounds are astonishingly similar in Turkey, where I saw them commonly beginning in mid-March. Radde and Walter (1889) report a surge of birds into Turkman on March 8 and 9 and along the Atreka River in the Meshed-Messerian desert between March 12 and April 1; Spangenberg (1936) located arriving imperials along the Syr-Darya River on March 23. Further east these birds usually appear during the first two weeks in April.

Migration routes are not as yet well defined, but the distances covered can be substantial. Some birds, raised in southwestern Siberia presumably must cross the high ranges of the Hindu Kush to reach wintering grounds in southern Iran, West Pakistan, and India, a distance of at least a thousand miles. According to Whistler (43) innumerable flocks may be observed every morning, following the same route or course on their movement between winter and summer ranges. He further notes that the periodicity of migrations of this species is often almost as marked as is that of Indian cranes. The long daily flights to water, characteristic of this species throughout the year, have already been mentioned.

The division of imperials into sex packs was not noted by Program personnel though Baker (3) indicates that flocks entering the winter range in Rajasthan are often of one sex with the birds intermingling with the opposite sex soon thereafter.

Like the common sandgrouse, the imperial exhibits rather regular daily movements. Whistler (44), speaking of the imperial sandgrouse in the Thar Desert, describes these as follows: "in the morning about 8 to 10 a.m. they fly to water to drink, all the flocks in the neighbourhood using the same place; after drinking they fly to the feeding ground which is bare open country with an occasional straggling bush or two, lying fallow after a rabi (greens, legumes, mustard) crop; here they find grains of that crop and the seeds of weeds. While feeding they keep close together and move with much deliberation, looking in the distance rather like a collection of mud-turtles. They remain, if not disturbed, on this ground till the evening; when a proportion again fly to drink and then they collect at the 'jugging' places which are usually in the young kharif crops and which may be recognized by the abundance of footmarks and droppings." The propensity of these birds to rest in a dusty spot under the hot midday sun has already been mentioned.

## Flight

These birds are exceptionally strong on the wing as well as swift and direct in flight. Whistler (41) quotes Colonel Meinertzhagen as indicating 43 to 47 miles an hour to be the normal flight speed of sandgrouse. Dement'ev (15) says that the flight is swift but slower than that of the Tibetan sandgrouse. Resting birds, when flushed, have a habit of springing almost straight up 5 to 10 feet before winging away. In Turkey and Iraq it was normal for them to rise at long shot-gun range and either to fly out of sight over the horizon or to circle briefly and alight a short distance away.

## Wariness

The imperial is the wildest and shyest of the Asian sandgrouse. Its inclination to seek new waterholes when disturbed at its customary drinking place has been mentioned. Where not much hunted, one may not even require a blind to secure excellent bags but by the second day of shooting many birds will flair off well out of range of a man dressed in aught but the native garb.

## Resting and Roosting

Except for flights to water or for food, these birds rest on the ground in open plains, fallow fields or in the dust of the cart tracks that pass for roads. Much the same locations are selected for roosting. When walking or driving over the desert at night it is not unusual to put up small groups that disappear into the night with a whistle of wings.

## Breeding

In Turkey the birds were usually paired off before or shortly after their arrival from the south in March. Breeding may take place shortly thereafter though Dement'ev indicates that in Siberia the breeding season starts by April which is later than in Turkey. Breeding may continue into August in Turkey and likewise in Siberia where Zarudny (1896) found well-developed eggs in 5 of 11 females shot on July 20. Of 27 females killed on August 10 by him, 20 had long since completed egg laying, 5 had just finished, and in 2, eggs ready to be laid were still present in the oviduct.

## Nesting and Renesting

Imperial sandgrouse nests are mere unlined hollows located in an open spot or semishaded by a stone or vegetation. The normal clutch consists of 2 or 3 eggs.

Recorded nesting dates vary from mid-April to August. Full complements of eggs were collected in mid-April in North Africa (Whitaker, 45) and equally early nests were reported to me in central Turkey. Unfavorable weather conditions are said to cause a recession of the reproductive



Figure 36. Imperial sandgrouse fly swift and straight



Figure 37. The female imperial sandgrouse at the nest shades the eggs with slightly extended wings during the heat of the day

cycle. Isakov (in Dement'ev, 15) noted this at Kara-Bogaza in 1939 where an unusual spring drought resulted in the reabsorption of partly developed eggs. Barnes found imperials nesting in Afghanistan in May (in Oates, 28). Whistler (43) indicates that they commonly nest in the southeastern part of that country in May and June. I collected a young bird, not over three weeks old, high up on the central plateau of Afghanistan in early July. On August 29, west of Konya, Turkey, I purchased three youngsters not over two weeks old from local villagers and on the same day found a female on a nest containing two slightly incubated eggs. The nest was in an exposed location between short, scraggly clumps of grass. The temperature of the air was 102°F., and a thermometer placed next to the nest but in the sun registered over 140°F. When first located the female was standing with wings half outspread in an obvious attempt to provide shade for the eggs.

Both sexes apparently incubate the eggs. Austin (2) reports that the female sits on the eggs by day, the male by night, and that the period of incubation is 23 to 28 days. Dement'ev (15) states that incubation begins with the laying of the first egg because of the necessity of shading the eggs from the heat of the sun.

No exact information on renesting or second nests has come to light. There is a wide span from April and August between which nests have been located. Pigeons and doves, with which the sandgrouse are taxonomically related, often produce several clutches of eggs. Considering these facts, it would not be abnormal to find renesting the rule and second nests not uncommon.

### Eggs

The eggs are elliptical in shape with a smooth texture and a marked gloss. The shell is reported as brittle. Ground color is dull and pale, varying from cream to buff or greenish gray. Shell markings show indefinite smudges, blotches, and spots of brown of various shades, with secondary markings of lavender and purplish gray. The average egg size noted by Whistler (44) is 46.5 by 31.8 mm.

### Brooding and Rearing

As with many pigeons, brooding is done by both parents. According to Baker (3) the precocial young of sandgrouse differ greatly from the almost naked newly hatched squabs of pigeons and doves in being covered with richly colored down, being able to run at once and, to some extent, feed themselves. The young probably are capable of short flights by two weeks of age.

### Gregariousness

Imperial sandgrouse are, in general, much less gregarious than are either the pin-tailed or the common Indian sandgrouse, even in winter. Concentrations of from 1,000 to 8,000 birds around water has been reported from Saudi Arabia by Meinertzhagen (26) and from Rajasthan, by

Baker (3) and Christensen (14). Whistler (42) quotes Hume as observing a group of fully 2,000 birds so closely packed together as to occupy a space but 30 yards long by 10 yard wide. In our experience these are exceptional for we found parties of a few to several hundred birds to be the general rule on wintering grounds in the Iberian peninsula and in the Middle East. The illusion of larger flocks often is created by noting a constant stream of birds coming to and leaving the watering places without realizing that these aggregations subsequently tend to break up into much smaller groups.

This is particularly true on the breeding grounds in Turkey and Iran where, early in the morning, one could observe pairs or small parties of birds collecting into larger flocks on their way to drink and breaking up again upon leaving these waterholes. On the open Anatolian plains pairs or flocks of up to a few dozen birds were the rule from April through October.

### Psychology and Behavior

Imperial sandgrouse are gregarious, rather even-tempered and are not pugnacious. Pair or flock responses are the normal even in captivity. In Turkey, chukars, black francolins, and Turkish gray partridge (Perdix p. canescens) were penned together with imperial sandgrouse without difficulty except for the occasional bowling over of the slower-moving sandgrouse by other birds when frightened. Common Indian sandgrouse and imperials penned together in India reacted almost as though they were the same species. Both groups were surprisingly placid in captivity until frightened by the biologist in the course of providing food and water. On such occasions the entire group would spring straight upwards into the air, calling repeatedly and flying about. Momentum lost, they then fluttered to the soft sand floor where they immediately regained their composure. Freshly penned sandgrouse, when confined in a screened pen lined with cheesecloth, were observed to doze, dust, preen their feathers, eat, and drink with little signs of fear.

### Calls

Most sandgrouse have distinctive, almost ventriloquistic call notes. These vary but little and are constantly uttered in flight. Though not loud they carry so well that it is normal to detect the approach of a flock of imperial sandgrouse by hearing a fairly loud, clucking, musical "churr-churr-rur-rur" considerably in advance of locating them in the air. Birds on the ground will call occasionally to a passing flock; otherwise they are silent.

### Interbreeding

Present records do not indicate any crossing of the imperial sandgrouse with other species of sandgrouse even though the ranges of several species overlap.

## Predation

The imperial sandgrouse does not appear to be particularly susceptible to predation. In the semidesert areas of Turkey both avian and ground predators were much in evidence. Foxes were so common that I averaged seeing one for every 10 to 15 miles of night driving, in many areas. Snakes and lizards of a size sufficient to destroy the eggs of the imperial sandgrouse were occasionally contacted. Slow-flying hawks were abundant; prairie falcons frequently were seen. In the Thar Desert of India these were seen in close association with sandgrouse, but it is doubtful whether mortality from this cause is great. During live-trapping operations falcons do cause some harassment. Attracted by the struggling trapped birds, they may take advantage of this artificial situation by dropping into the nets. Ground predators probably cause little loss to the wary imperial sandgrouse.

On the Tigris, Meinertzhagen (26) reports that after a flock of imperial sandgrouse landed in deep water to drink, one of the birds was sucked under with a squelch by a large fish. Normally this sandgrouse alights first on land then walks to the water's edge for drinking.

## Reproductive Capacity

The reproductive capacity of the imperial sandgrouse is low but the survival rate of the broods appears to be substantial.

Breeding age -- Imperial sandgrouse breed the first year following hatching.

Number of eggs -- Normally 2 to 3 eggs are laid, a clutch similar in size to that of other sandgrouse.

Brood survival -- Considered high.

Life span -- Unknown

Sex ratio -- Not definitely known but appears to be closely balanced in the wild.

Renesting -- Renesting almost certainly if the first clutch is destroyed before hatching.

Second broods -- Probable though currently unproven. Baker (3) indicates that the common Indian sandgrouse nests at least twice each year.

## Diseases and Parasites

No extensive work seems to have been carried out on the diseases or parasites that infect imperial sandgrouse. Three specimens shot in central Turkey were sent to Carl Borg, Swedish wildlife pathologist, in 1950 for examination. No parasites were found. Blood smears from two were negative; in those from the third bird a few Haemogregarinas, protozoa of the class Sporozoa, were found. (a)

Among the few imperials trapped and conditioned for two months by Program personnel, losses, except from mechanical injuries, were unusual. Parasites, either internal or external, were not commonly observed in making postmortems of the few birds that died in captivity. No outbreak of disease was noted even though on one occasion in India both the imperial and the common Indian sandgrouse were penned within 50 feet of gray francolins that had to be destroyed because of Newcastle disease. In fact, imperials appeared to be remarkably unaffected by the diseases common to francolins or other gallinaceous birds studied by Program personnel in India.

## Analysis of Competing Interests

### Relation to Agriculture

In no portion of their wide range are imperial sandgrouse considered to be either injurious or beneficial to agricultural crops. Though they consume more waste grain than do most other sandgrouse, farmers do not accuse them of digging or pulling up freshly planted or sprouted cereals. Nor do they bother standing grain, fruits, or leafy crops. Unlike the vast packs characteristic of the pin-tailed sandgrouse, the imperial is seldom noticed on its feeding grounds except in pairs or small flocks.

### Usefulness

As a source of food -- Opinions vary as regards the edibility of the imperial sandgrouse. The meat is inclined to be dark and dry. Members of the British Mesopotamia Expedition (27), accustomed to army fare, characterized it as palatable but dry and tough. Ogilve-Grant (30) indicates that "the flesh is mixed brown and white on the breast, somewhat tough when fresh, and is reckoned delicious eating; indeed one writer says it is the finest game bird for the table in India." Whitaker (45) likens the meat to that of black grouse (Lyrurus tetrix). In Turkey, my friends and I cooked a number of imperials with thoroughly disillusioning results. But in Baghdad there was an Indian cook, wise in the preparation of this bird. His method was to hang the freshly shot imperials for a day at about 90°F., then skin, eviscerate, cut up and soak in vinegar, salt, and water for another day. Thus tenderized, and then broiled and basted with brandy, they were delicious.

(a) Karl Borg, personal communication

Two of his favorite recipes for sandgrouse are given below:

#### Sandgrouse in Milk

2 sandgrouse	4 small cups of milk or half
8 small onions	milk and half stock
8 small carrots	salt and pepper
8 small potatoes	flour
1 bay leaf	

Clean the sandgrouse. Prepare the vegetables, but do not chop them unless they are large, in which case use half the number. Put the sandgrouse in a fireproof dish or pan and surround with the vegetables. Pour over the heated milk and stock and cook in a medium oven for about 2 hours, but do not let the milk boil. When nearly cooked, season to taste.

When the birds are tender, remove them, cut them in half, put them on a serving dish surrounded by vegetables and keep them hot in the oven. Measure the liquid and to each tin (cup) add 2 tablespoonfuls of flour mixed with a little cold water till smooth. Bring to the boil, season, cook for a few minutes, and pour over the sandgrouse and vegetables.

The milkstock may be used for making bread sauce or horse-radish sauce, if that is preferred.

#### Sandgrouse Paste

3 sandgrouse	$\frac{1}{2}$ small cup of butter
1 black partridge	pepper and salt

Roast all the birds, and while they are still hot remove and mince the meat of the sandgrouse breasts and all the meat of the black partridge. Add pepper, salt, and butter, and work the paste with a wooden spoon until all the butter disappears. Spread on a flat plate covering it to the very edge. The paste should be about 1-3/4 inches thick. When cold, cut in wedges and serve.

Tomato catsup, Worcester sauce, and even sherry may be added to the paste according to taste, but they are not necessary.

As a game bird -- To me, shooting imperial sandgrouse, as they fly to water, is like duck hunting on dry land. The birds fly straight and fast. After an initial baptism of fire they rapidly become wary, and this requires shooting from a blind if many birds are to be bagged.



Like ducks they circle the waterhole several times before alighting and, if suspicious of danger, they seek another place to settle down, even though it is at a considerable distance. It is surprisingly difficult to bring down a bird, and shot smaller than No. 6 is astonishingly ineffective except at close range. As with ducks, several days of shooting at a waterhole is sufficient to drive most of the birds away for periods up to 2 to 3 weeks in length.

In Turkey normal first-day bags for two guns were 10 to 20 birds, though occasionally more were shot. In India the hunting of imperial sandgrouse was usually reserved for Maharajahs and their important guests. The most famous shoot was that of the Maharajah of Bikaner in the desert of north central Rajasthan. Shooting was from concrete blinds constructed along the almost level banks of the tank (small lake) at Gajner and was so well organized that birds were encouraged to concentrate here by being denied access to all other waterholes for a dozen miles around. Here, in 1921 a party of 12 guns including Lord Rawlinson and the Maharajah harvested 5,968 sandgrouse in two consecutive morning shoots (Burton, 9). Similar hunts, though on a much smaller scale, were the rule in other parts of Rajasthan and West Pakistan wherever the imperial wintered in sizable numbers.

In recent years some diminution in the abundance of imperial sandgrouse has been reported even though the occasional massive slaughtering of birds at waterholes has been largely a thing of the past for 10 to 15 years. Watering areas for sandgrouse that once required a day's ride by horseback to reach are now only a matter of hours away by jeep. Today fewer birds fall to one gun, but there are many more guns afield. Still this bird, over most of its range, maintains its numbers surprisingly well in the face of heavy hunting pressure.

The pursuit of birds on the open range can be a frustrating experience. Imperials normally flush at long shotgun range, from a hunter on foot, though they may often be more closely approached with a jeep. In the old days, knowledgeable hunters made use of camels or donkeys behind which they cautiously approached a sitting bird. As can be imagined, skill, patience, and plenty of time were the ingredients then required to collect even a modest bag.

#### Relation to Other Game Birds

Within the moister parts of the range of the imperial sandgrouse, both winter and summer, are found other game birds that inhabit semi-arid tracts. Included among these are other sandgrouse, doves, gray francolins, and bustards. When precipitation is above 10 inches a year in Spain one may also find red-legged partridges. Watering places are shared by all these without trouble. Feeding areas are widespread, as are nesting sites. No signs of antagonism or of territorial aggressiveness were observed or have been reported in the literature dealing with these species.

## Breeding and Raising

Two attempts at breeding a limited number of wild-trapped imperial sandgrouse under game farm conditions were made in the United States between 1954 and 1963. Six birds from Turkey were made available to Dr. J. Stokley Ligon at Carlsbad, N. Mex., in 1954 for trial propagation. Over several years six eggs were laid but no chicks were hatched therefrom. Between 1960 and 1961, 21 imperials from Rajasthan were supplied to the Utah State game farm at Price by the Nevada Fish and Game Department. No eggs have been received from these birds. Perhaps it is not feasible to propagate this species on game farms. Wild-trapping operations would appear to be a more successful way of providing the numbers of imperial sandgrouse required for trial release in the United States.

Bannerman (4) notes that a village official near Nicosia, Cyprus, raised three young imperial sandgrouse collected from a wild nest and that the birds eventually grew to be quite tame. I raised a similar number of very young birds, secured in central Turkey, on small seeds, without difficulty. When almost full grown these, together with a few adult birds, were shipped to Dr. Ligon.

## Trapping

The problem of trapping sandgrouse in large numbers, usually at waterholes, appeared not to be complicated. Baker (3) reports that "many are caught in western India in nets and snares at drinking places. Nets about 6 feet in height were placed close to the water in the line of flight and kept erect by sticks so set as to fall over at the first impact. Nooses are placed in great numbers at the water's edge, either pegged down singly or attached in rows to one, long string weighted down at either end. In Iran (imperial) sandgrouse are caught by spotlighting flying birds when they are said to fall down through the beam into your hand."

Cannon nets might have worked well but were not available to us in Turkey. Though natives in the mountains were catching thousands of chukars with horsehair foot snares, an early trial of this device brought only an occasional bird to hand because sandgrouse do not walk around much at the waterhole.

Between 1950 and 1953 several other attempts to catch imperial sandgrouse were made. My report (6) of this unsuccessful project is given below.

"The following were employed at watering places frequented by several hundred birds, all to no avail:

"1. Funnel traps baited with grain. No birds were caught since they apparently eat but sparingly when seeking water.

"2. Scattering grain soaked in alcohol or with a tranquilizing solution. The results were untested for the reason given above.

"3. Funnel traps with wings 18 inches high extending for 100 feet in either direction from the entrances and separating the landing field from available water. Most birds became suspicious of the dark netting and left for other familiar water holes after a preliminary investigation. A few walked to the netting and flew over to water.

"4. A fine mesh net 15 feet high and 100 feet long extended into the air at one end of the landing field. This was tried only on the last day. When leaving the ground sandgrouse have a habit of springing straight up into the air so that birds only 20 feet away either topped the net or saw it and went around."

In 1961-62 Christensen (14) located Indian trappers who specialized in netting sandgrouse. Although not concentrating on catching imperials, he and his trappers found the same procedures as are detailed on pages 22 to 23 for trapping the common Indian sandgrouse, to be fairly effective. By utilizing these procedures in the summer range of the imperial in Turkey catching large numbers of these birds should pose no great problems.



Figure 38. Sandgrouse are easy to keep in captivity but the problem of securing eggs from such birds has not as yet been resolved

Table 6. Average maximum and average minimum temperatures by months for  
49 stations within the range of the imperial sandgrouse (a)

Country	Station		Months												Range
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Spain	Seville	max	60	64	67	75	79	90	98	97	90	79	69	60	Breeding and Summer
		min	42	43	47	52	56	63	67	68	64	57	50	44	
	Salamanca	max	47	51	58	63	68	79	89	86	75	66	55	47	"
		min	30	30	35	41	44	51	54	55	50	42	35	31	
	Zamora	max	46	51	57	63	68	79	85	85	77	65	54	46	"
		min	32	33	37	42	46	52	56	56	54	45	37	32	
	Segovia	max	43	47	55	61	66	76	85	84	71	53	50	43	"
		min	30	31	36	40	45	50	57	57	52	44	36	31	
Spanish Sahara	Tantan	max	77	84	93	92	91	96	104	98	102	95	90	81	Breeding and Summer
		min	44	44	48	50	55	58	60	60	59	53	50	42	
Morocco	Ait Ourir	max	71	78	87	89	95	103	112	110	104	93	85	74	Breeding and Summer
		min	34	35	40	44	46	54	58	58	53	49	42	37	
	Bouarfafa	max	64	69	77	85	92	100	105	104	99	88	76	66	"
		min	28	27	32	36	38	49	58	59	51	42	36	29	
Algeria	Biskra	max	69	74	79	92	98	108	114	111	105	93	80	71	Resident
		min	36	39	43	48	56	66	73	72	63	53	44	38	
	Boghari	max	57	62	70	79	87	94	101	100	94	82	69	57	Winter
		min	27	29	31	34	41	49	56	58	49	42	34	26	
	Mesheria	max	63	69	75	83	84	97	101	101	95	83	73	63	Breeding and Summer
		min	27	27	31	35	40	50	60	59	50	41	32	27	
	Djelfa	max	61	66	72	81	86	95	100	99	92	81	69	64	Resident
		min	19	21	26	27	33	44	49	49	42	34	27	22	
Tunisia	Gofsa	max	65	73	80	89	96	104	109	107	101	90	77	67	Breeding and Summer
		min	32	35	37	43	50	59	65	65	59	49	40	32	
	Remada	max	67	77	88	96	102	111	113	109	103	98	84	76	"
		min	34	38	41	45	54	58	64	64	63	53	44	38	
Turkey	Adana	max	65	69	78	87	96	100	99	101	99	95	85	71	Resident
		min	28	30	33	40	51	57	64	66	57	50	39	32	
	Van	max	43	47	52	63	77	85	91	91	87	75	61	49	Breeding and Summer
		min	1	1	6	20	33	41	49	48	42	28	22	5	
	Konya	max	39	44	52	63	72	79	86	86	78	69	56	46	Resident
		min	23	24	29	38	47	54	58	59	50	42	34	28	

(a) Temperatures in degrees F.

Table 6 Average maximum and average minimum temperatures by months for  
49 stations within the range of the imperial sandgrouse (Continued)

Country	Station		Months												Range
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Turkey (cont'd.)	Nigde	max	40	43	51	62	71	80	85	87	78	69	54	44	Breeding and Summer
		min	24	27	29	40	47	53	58	58	51	44	34	26	
	Eskisehir	max	38	42	52	64	71	79	83	85	77	69	56	42	"
		min	24	25	29	38	46	51	56	56	48	41	35	28	
	Kirsehir	max	40	43	51	63	72	79	85	85	79	69	56	44	Resident
		min	23	26	30	38	48	54	59	60	51	43	35	28	
	Urfa	max	48	53	60	72	85	94	99	101	93	80	67	54	"
		min	33	36	39	47	57	66	74	73	66	56	47	38	
	Gaziantep	max	42	48	53	66	77	88	93	93	86	73	60	48	"
		min	30	33	35	44	52	63	69	68	58	49	41	32	
	Mardin	max	40	45	50	63	76	88	94	94	86	72	59	47	"
		min	33	36	39	49	60	69	74	77	68	56	46	38	
	Elazig	max	36	39	48	63	75	85	92	91	84	69	55	42	Breeding and Summer
		min	24	25	31	43	53	61	64	67	60	49	40	30	
Syria	Aleppo	max	59	63	76	88	97	105	107	107	100	92	77	63	Winter
		min	23	24	27	35	45	53	63	63	49	46	33	26	
	Damascus	max	62	69	78	91	94	100	102	105	99	89	80	64	"
		min	28	30	31	38	46	53	56	57	52	48	37	31	
	Deir-ez-zor	max	65	67	85	97	100	108	111	110	107	95	84	66	"
		min	25	27	31	42	53	60	70	71	54	50	33	27	
Iraq	Mosul	max	54	58	69	78	92	103	109	109	102	88	72	58	Winter
		min	35	38	41	49	58	65	72	70	61	52	46	38	
Saudi Arabia	Riyadh	max	84	90	96	101	107	112	112	110	108	99	92	81	Winter
		min	32	37	41	48	63	70	69	68	64	53	46	37	
	Hail	max	78	81	88	92	103	106	108	107	103	99	91	73	"
		min	30	26	30	38	52	60	65	60	61	55	43	33	
Jordan	Amman	max	65	71	80	90	97	99	98	100	98	92	83	70	Winter
		min	32	33	34	37	46	52	58	58	55	49	41	34	
Iran	Isfahan	max	58	64	73	81	91	100	103	101	96	87	74	62	Winter
		min	15	18	27	37	46	56	60	57	50	39	29	20	
	Teheran	max	55	61	74	82	91	99	104	102	96	85	73	60	Resident
		min	18	19	28	37	47	57	65	64	56	44	33	24	
	Meshed	max	61	63	76	84	92	98	99	98	93	91	77	63	"
		min	4	12	22	34	46	52	55	50	42	32	23	18	

Table 6. Average maximum and average minimum temperatures by months for  
49 stations within the range of the imperial sandgrouse (Continued)

Country	Station		Months												Range
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
West Pakistan	Quetta	max	50	54	64	74	84	92	94	92	86	76	65	55	Winter
		min	28	31	38	46	52	59	65	62	50	39	32	28	
	Bahawalpur	max	70	76	86	96	106	108	103	101	100	96	85	74	"
		min	40	47	55	65	76	83	84	82	76	62	51	44	
India	Jodhpur	max	76	80	90	100	105	103	97	92	94	95	88	79	Winter
		min	49	53	61	71	79	82	80	77	75	65	55	50	
	Bikaner	max	72	77	89	99	107	107	101	97	98	96	85	75	"
		min	47	52	62	73	82	85	83	80	78	70	58	49	
	Hissar	max	71	76	88	98	105	106	100	96	97	95	84	74	"
		min	41	47	57	67	76	82	81	79	74	63	50	43	
	Barmer	max	76	81	90	100	106	103	96	92	95	97	89	80	"
		min	50	56	64	74	80	80	79	77	76	70	61	53	
	Ambala	max	69	73	84	96	104	104	96	93	94	92	82	72	"
		min	43	48	56	66	76	81	79	78	74	62	50	44	
Afghan-istan	Baglan	max	49	56	65	72	81	97	99	94	88	76	52	49	Breeding and Summer
		min	35	34	43	51	54	62	65	61	52	42	30	32	
	Mazar-i-sherif	max	52	58	67	72	81	98	103	97	88	76	66	50	"
		min	35	38	44	52	56	67	72	65	61	49	31	36	
	Kabul	max	52	59	68	77	83	97	101	95	88	76	53	52	"
		min	36	36	45	54	60	72	76	72	61	48	31	36	
U.S.S.R.	Alma-Ata	max	41	44	63	76	84	90	94	93	86	75	61	48	Breeding and Summer
		min	-13	-10	3	23	37	47	52	47	36	17	4	-4	
	Ashkhabad	max	60	68	80	91	101	105	106	104	99	89	79	68	Resident
		min	5	17	24	37	49	57	63	57	44	33	23	18	
	Kazalinsk	max	34	38	56	78	92	100	102	99	91	74	57	41	Breeding and Summer
		min	-16	-14	-8	23	38	49	55	52	40	22	5	-7	
	Kokpekty	max	22	28	38	65	82	90	92	90	82	63	43	28	"
		min	-41	-34	-27	3	23	37	43	40	25	5	-23	-34	
	Tashkent	max	56	62	73	84	94	99	101	99	92	83	75	63	Resident
		min	-3	7	21	31	42	50	54	50	41	27	17	12	
	Tyub-karagan	max	42	42	57	74	81	90	95	92	84	70	57	47	"
		min	2	6	12	33	45	52	62	57	43	31	19	10	

Table 7. Average monthly and annual precipitation in inches at 49 stations within the range of the imperial sandgrouse

Country	Station	Precipitation by Months												Total	Range
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Spain	Seville	2.7	2.4	3.1	2.4	1.7	0.3	0.1	0.2	1.1	2.5	2.6	3.3	22.4	Br. & Su.
	Salamanca	1.6	1.2	1.9	1.3	1.8	0.9	0.4	0.6	0.6	1.4	1.6	2.0	15.3	"
	Zamora	1.4	0.9	1.3	1.2	1.6	1.0	0.2	0.4	0.7	1.2	1.2	1.5	12.6	"
	Segovia	1.4	1.2	1.7	1.7	2.5	1.2	0.9	0.5	1.0	1.7	2.1	1.9	17.8	"
Sp. Sahara	Tantan	0.2	0.1	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	1.0	1.8	3.8	"
Morocco	Ait Ourir	1.2	1.5	2.1	2.2	1.0	0.5	0.1	0.1	0.5	1.1	1.9	1.5	13.8	"
	Bouarfa	0.4	0.5	0.9	0.7	0.7	0.3	0.1	0.3	0.9	0.7	0.9	0.8	7.2	"
Algeria	Biskra	0.7	0.4	0.7	0.4	0.6	0.3	0.1	0.1	0.7	0.6	0.9	0.7	6.2	Resident
	Boghari	2.2	1.8	1.5	1.1	1.5	0.8	0.2	0.4	0.9	1.3	1.9	2.3	15.9	Winter
	Mesheria	0.8	0.9	1.3	1.1	1.0	0.6	0.2	0.3	1.3	1.1	1.7	1.1	11.4	
	Djelfa	1.3	1.1	1.1	0.8	1.4	0.9	0.2	0.4	1.2	0.9	1.3	1.4	12.0	
Tunisia	Gofsa	0.7	0.5	0.9	0.6	0.4	0.3	0.1	0.2	0.5	0.5	0.7	0.5	5.9	Br. & Su.
	Remada	0.5	0.2	0.3	0.1	0.2	0.1	0.0	0.1	0.0	0.4	0.1	0.2	2.0	"
Turkey	Adana	4.3	4.0	2.5	1.6	2.0	0.7	0.2	0.2	0.7	1.9	2.4	3.8	24.3	Resident
	Van	2.2	1.6	2.0	2.3	1.4	0.6	0.2	0.1	0.3	2.0	1.5	1.3	15.5	Br. & Su.
	Konya	1.7	1.3	1.2	1.2	1.6	1.0	0.2	0.1	0.6	1.3	1.2	1.7	13.1	Resident
	Nigde	2.0	1.3	1.2	1.5	1.8	1.1	0.2	0.5	0.6	1.2	1.5	1.8	13.6	Br. & Su.
	Eskisehir	1.5	1.3	1.0	1.3	1.9	1.2	0.5	0.2	0.7	1.0	1.4	1.8	13.8	"
	Kirsehir	1.9	1.3	1.4	1.3	1.8	1.3	0.2	0.3	0.5	1.0	1.3	2.1	14.4	Resident
	Urfa	4.4	2.8	2.0	1.8	0.6	0.1	0.0	0.0	0.1	0.9	1.9	2.7	17.3	"
	Gaziantep	5.1	3.4	3.0	2.3	0.9	0.3	0.0	0.2	0.1	2.0	2.7	3.9	23.9	"
	Mardin	5.9	3.5	4.2	3.1	1.4	0.1	0.0	0.0	0.0	1.4	3.9	4.1	27.6	"
	Elazig	1.6	2.0	1.8	2.5	1.7	0.6	0.1	0.1	0.3	1.8	2.4	1.7	16.6	Br. & Su.
Syria	Aleppo	3.5	2.5	1.5	1.1	0.3	0.1	0.0	0.1	0.1	1.0	2.2	3.3	15.5	Winter
	Damascus	1.7	1.7	0.3	0.5	0.1	0.1	0.1	0.0	0.7	0.4	1.6	1.6	8.6	"
	Deir-ez-zor	1.6	0.8	0.3	0.8	0.1	0.1	0.0	0.0	0.0	0.2	1.5	0.9	6.2	"
Iraq	Mosul	2.7	2.7	1.8	1.8	0.6	T	T	0.0	T	0.8	2.1	2.3	14.6	Winter
Saudi Arabia	Riyadh	0.1	0.8	0.9	1.0	0.4	0.1	0.0	0.1	0.0	0.0	0.1	0.1	3.2	Winter
	Hail	0.4	0.6	0.5	0.2	0.4	0.0	0.0	0.0	0.0	0.1	1.3	0.5	3.9	"
Jordan	Amman	2.7	2.9	1.2	0.6	0.2	0.0	0.0	0.0	0.1	0.2	1.3	1.8	10.9	Winter
Iran	Isfahan	0.6	0.4	1.0	0.6	0.2	0.1	0.1	0.1	0.1	0.1	0.6	0.8	4.3	Winter
	Teheran	1.8	1.5	1.8	1.4	0.5	0.1	0.1	0.1	0.1	0.3	0.8	1.2	9.7	Resident
	Meshed	0.8	1.0	2.2	1.8	1.2	0.3	0.1	0.1	0.1	0.4	0.6	0.7	9.1	"

Table 7. Average monthly and annual precipitation in inches at 49  
stations within the range of the imperial sandgrouse (Continued)

Country	Station	Precipitation by Months												Total	Range
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
W. Pakistan	Quetta	1.9	2.0	1.7	1.0	0.4	0.2	0.5	0.3	0.1	0.1	0.3	1.0	9.5	Winter
	Bahawalpur	0.2	0.3	0.4	0.2	0.2	0.3	2.4	1.3	0.1	0.1	0.0	0.2	5.7	"
India	Jodhpur	0.2	0.2	0.1	0.1	0.4	1.4	4.0	4.8	2.4	0.3	0.1	0.1	14.1	Winter
	Bikaner	0.3	0.3	0.2	0.2	0.6	1.2	3.3	3.6	1.3	0.2	0.1	0.2	11.5	"
	Hissar	0.5	0.5	0.6	0.3	0.5	1.3	4.3	4.9	2.8	0.6	0.1	0.4	16.8	"
	Barmer	0.2	0.3	0.2	0.2	0.4	1.1	3.2	5.3	0.7	0.1	0.1	0.1	11.9	"
	Ambala	1.3	1.9	0.9	0.6	0.7	3.0	9.6	7.9	5.1	0.9	0.2	0.8	32.9	"
Afghanistan	Baglan	1.4	1.3	2.0	2.6	1.6	T	0.0	0.0	T	T	0.5	0.6	10.0	Br. & Su.
	Mazar-i-sheerif	0.5	4.9	2.9	1.5	1.3	T	0.0	T	T	T	0.5	1.2	12.8	"
	Kabul	1.8	1.2	2.0	1.1	1.1	0.0	0.0	0.0	T	0.0	T	0.5	7.7	"
U.S.S.R.	Alma-Ata	1.3	0.9	2.2	4.0	3.7	2.6	1.4	1.2	1.0	2.0	1.9	1.3	23.5	Br. & Su.
	Ashkhabad	1.0	0.8	1.9	1.4	1.2	0.3	0.1	0.1	0.1	0.5	0.8	0.7	8.9	Resident
	Kazalinsk	0.4	0.4	0.5	0.5	0.6	0.2	0.2	0.3	0.3	0.4	0.5	0.6	4.9	Br. & Su.
	Kokpekty	1.0	0.6	0.3	0.5	1.0	1.3	1.2	0.9	0.6	0.9	1.4	1.2	11.0	Br. & Su.
	Tashkent	2.1	1.1	2.6	2.3	1.4	0.5	0.2	0.1	0.1	1.2	1.5	1.6	14.7	Resident
	Tyub-karagan	0.4	0.1	0.4	0.5	0.7	0.3	0.2	0.6	0.6	0.3	0.3	0.6	5.1	Resident



## REFERENCES

1. Arevalo, D. J., and Baca. 1887. Aves de Espana. Viuda e Hijo de Aguada. pp. 471.
2. Austin, O. L., Jr. 1961. Birds of the world. Golden Press, New York. pp. 316.
3. Baker, E. C. S. 1928. The Fauna of British India including Ceylon and Burma. Birds. Vol. 5. Taylor and Francis, London. pp. 469.
4. Bannerman, D. A., and W. M. Bannerman. 1958. Birds of Cyprus. Oliver and Boyd, London. pp. 286-290.
5. Bodenheimer, F. S. 1935. Animal life in Palestine. Sefer, Tel-Aviv. pp. 506.
6. Bump, G. 1950. Operation sandgrouse - Houbara (middle-sized bustards) and oriental sandgrouse in Turkey, Iran and Iraq. Typewritten report to Division of Sport Fisheries and Wildlife, Washington. p. 2.
7. \_\_\_\_\_ 1950. Special report on Iran. Typewritten report to Division of Sport Fisheries and Wildlife, Washington.
8. \_\_\_\_\_ 1950. Operation sandgrouse - Ankara to Kirsehir, Aksary, Konya and Polati. Typewritten report to Division of Sport Fisheries and Wildlife, Washington. p. 2.
9. Burton, R. W. 1952. A history of shikar in India. Jour.B.N.H.S. Vol. 50:4 pp. 845-849.
10. Cave, F. O., and J. A. MacDonald. 1955. Birds of the Sudan. Oliver and Boyd, London. pp. 162-164.
11. Christensen, G. C. 1962. Use of the clap net for capturing Indian sandgrouse. Jour. Wildlf. Mgt. 26:4. pp. 399-402.
12. \_\_\_\_\_ 1963. Sandgrouse released in Nevada found in Mexico. The Condor. Vol. 65:1. pp. 67-68.
13. \_\_\_\_\_ 1963. Exotic game bird introductions into Nevada. Biological Bull. No. 3. Nevada Fish and Game Commission, Reno. pp. 66.
14. \_\_\_\_\_ 1963. The imperial sandgrouse in the Thar Desert of India. Biological Society of Nevada. Occasional papers. No. 2. pp. 7.
15. Dement'ev, G. P., N. A. Gladkov, IU. A. Isakov, N. N. Kartashev, S. V. Kirikov, A. V. Mikheev, and E. S. Ptushenko. 1952. Birds of the Soviet Union, Vol. 4 (Ptitsi Sovetskogo Soiuza, Tom. IV) \_\_\_\_\_, Moskva, Gosudarstvennoe Izdatel'stvo "Sovetskaia Nauka". pp. 640.

16. Dickson, H. R. P. 1949. The Arab in the desert. Allen and Unwin, London. pp. 648.
17. Dolgushin, D. I. 1962. Birds of Kazakhstan (Ptitsy Kazakhstana) Vol. 2. Kazak Academy of Science, Alma Alta, Kazak S.S.R., U.S.S.R. pp. 780.
18. Faruqi, S. A., G. Bump, P. C. Nanda, and G. C. Christensen. 1960. A study of the seasonal foods of the black francolin, grey francolin and the common sandgrouse in India and Pakistan. Jour. B.N.H.S. Vol. 57:2. pp. 1-8.
19. Great Britain. Meterological Office. 1960. Climates of the world. Meterological Office publication no. 617, London.
20. Grinnell, J., and A. H. Miller. 1944. The distribution of the birds of California. The Club-Berkeley.
21. Hume, A. O., and C.H. T. Marshall. 1879. The game birds of India, Burmah and Ceylon. Vol. 1. Calcutta Press Co., Calcutta. pp. 279.
22. Mackworth-Praed, C. W., and C. H. B. Grant. 1957. Birds of eastern and northeastern Africa. Series 1, Vol. 1. Longmans, Green and Co. London. pp. 445-457.
23. \_\_\_\_\_. 1962. Birds of the southern third of Africa. African handbook of birds. Longmans, Green and Co., Ltd., London. Series 2, Vol. 1. pp. 371-377.
24. Manager of Publications, Delhi. 1953. Climatological tables of observatories in India. Government Central Press. Bombay. pp. 508.
25. McLachlan, G. R., and R. Liversidge. 1961. Roberts: Birds of South Africa. Revised ed., third impression. Cape Times Ltd., Cape Town. pp. 163-165.
26. Meinertzhagen, R. 1954. Birds of Arabia. Oliver and Boyd, London. pp. 623.
27. Members of the Mesopotamia Expeditionary Force "D", 1915-1919. 1923. A survey of the fauna of Iraq. Times Press, Bombay. pp. 404.
28. Oates, E. W. 1890. Hume's nests and eggs of Indian birds. Vol. 3. R. H. Porter, London. pp. 461.
29. Ogilvie-Grant, W. R. 1893. Catalogue of the game birds in the collection of the British Museum. British Museum, London. pp. 585.
30. \_\_\_\_\_. 1895. A handbook of birds. Sandgrouse, partridges, pheasants. Vol. 1. W. H. Allen and Co., London. pp. 304.
31. Peters, J. L. 1937. Check-list of birds of the world. Vol. 3. Harvard University Press, Cambridge. pp. 3-10.

32. Ripley, S. D. 1961. A synopsis of the birds of India and Pakistan together with those of Nepal, Sikkim, Bhutan and Ceylon. Bombay Natural History Society, Bombay, pp. 703.
33. Robyns, W., and S. H. Lamb. 1939. Preliminary ecological survey of the island of Hawaii. Bulletin van. den Ryksplententuin, Deel XV., Brussels. pp. 241-293.
34. Rock, J. F. 1913. The indigenous trees of the Hawaiian Islands. Honolulu. pp. 518.
35. Schwartz, C. W., and E. R. Schwartz. 1949. The game birds in Hawaii. Board of Comm. of Agr. and Forests, Hawaii. pp. 168.
36. Singh, K. S. 1962. Helminths of India, Part 3. Nematoda. Wildlife Diseases 29. pp. 22.
37. State of Hawaii. 1963. Ecological appraisal of major game-deficient habitats, Hawaii. Division of Fish and Game, Honolulu.
38. U. S. Department of Agriculture. 1941. Climate and man. Yearbook of agriculture, Washington. pp. 1248.
39. Weather Bureau, U. S. Dept. of Commerce. 1953. Climatography of the United States, No. 11. U.S. Govt. Printing Office, Washington, D.C.
40. Voous, K. H. 1960. Atlas of European birds. T. Nelson and Sons, Ltd., London. pp. 284.
41. Whistler, H. 1930. The study of Indian birds. Part 4. Jour. B.N.H.S. Vol. 34:1. pp. 27-39.
42. \_\_\_\_\_ 1938. The ornithological survey of Jodhpur State. Jour. B.N.H.S. Vol. 40:2. pp. 213-235.
43. \_\_\_\_\_ 1945. Material for the ornithology of Afghanistan. Part 5. Jour. B.N.H.S. Vol. 45:4. pp. 462-485.
44. \_\_\_\_\_ 1949. Popular handbook of Indian birds. Fourth ed. revised. Gurney and Jackson, London. pp. 403-405.
45. Whitaker, J.I.S. 1905. The birds of Tunisia, Vol. 2. R. H. Porter. London. pp. 410.
46. Williams, C. H., and C. E. Williams. 1929. Some notes on the birds breeding round Quetta. Jour. B.N.H.S. Vol. 33:3. pp. 598-613.
47. Zohary, M. 1950. The flora of Iraq and its phytogeographical subdivision. Bull. 31. Government of Iraq. Directorate General of Agriculture, Baghdad. pp. 201.

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